THE

# AËRONAUTICAL JOURNAL.

(FOUNDED 1897 in succession to the ANNUAL REPORTS.)

THE ORGAN OF THE ROYAL AËRONAUTICAL SOCIETY.

*Published Monthly at the Offices of the Society, at 7, Albemarle Street, Piccadilly, London, W.1.*
*Telephone: "Gerrard 7373." Telegraphic Address: "Didaskalos, Piccy, London."*
*Subscription per annum, £1 12s. 6d.; single numbers, 2s. 9d., post free.*

**Edited for the Council by J. LAURENCE PRITCHARD, Fellow.**

*All communications should be addressed to the Editor.*

No. 131. NOVEMBER, 1921. VOL. XXV.

## Notices of the Royal Aëronautical Society.

### Election of Members.

The following members were elected at a meeting of the Council held on October 18th. Owing to various important matters which were on the agenda for discussion at that meeting, it is regretted that it was not possible to consider several applications for election to Associate Fellowship. These will, therefore, be considered at the next ordinary meeting of the Council:—

*Students.*—C. G. W. Ebbutt, W. S. Hollyhock, H. J. MacKintosh, N. S. Norway, C. A. Pike, F. Radcliffe, C. Russell, S. O. Smith, C. A. Wright.

*Associate Members.*—Mrs. J. E. M. Pritchard, T. Tateno.

*Foreign Member.*—T. Tanaka.

### Students' Discussion Meeting.

The first Students' Discussion Meeting was held in the Society's Library at 7.0 p.m., on October 13th, with Mr. H. B. Irving, B.Sc., Associate Fellow, in the chair, when Mr. T. A. Kirkup opened the proceedings with a paper on "A Comparison of Different Types of Aerofoils."

At the close of the meeting the following gentlemen were appointed a Provisional Committee to undertake arrangements for the present session:—Mr. W. H. Rossiter, Mr. L. J. Jones, with Mr. Stanley H. Evans as the Honorary Secretary.

### Donations.

The Council desire gratefully to acknowledge the receipt of a copy of "Strength of Materials," by G. Morley; "Aviation Engines," by V. W. Pagé; "Stability in Aviation," by G. H. Bryan; "The Diesel Engine," by G. J. Wells; and "Principles of Setting Out, Securing and Tooling Operations," by A. Parr, from Wing Commander H. Le M. Brock, D.S.O.; also a copy of "Theory of Airscrews," by A. Fage, from the Author.

### Airship Photographs.

A letter has been received from the Director of Research, Air Ministry, notifying the fact that it has been decided to present to the Society for placing in the Library for the information of members ten books of airship photographs collected as a record of various types of airships that were used during the war, "in acknowledgment of the Society's activities in the cause of aeronautics, more especially with regard to airships."

## R.38 Memorial Research Fund.

LIST OF DONATIONS TO OCTOBER 21ST.

| | £ | s. | d. |
|---|---|---|---|
| H.R.H. The Prince of Wales, K.G. ... ... ... ... | 10 | 0 | 0 |
| H.R.H. The Duke of York, K.G. ... ... ... ... | 5 | 0 | 0 |
| Rt. Hon. Lord Weir ... ... ... ... ... ... | 105 | 0 | 0 |
| Sir Alan Anderson ... ... ... ... ... ... ... | 105 | 0 | 0 |
| Messrs. Vickers, Ltd. ... ... ... ... ... ... | 105 | 0 | 0 |
| Lloyds, Royal Exchange ... ... ... ... ... ... | 100 | 0 | 0 |
| Council of the Royal Aeronautical Society ... ... ... | 65 | 0 | 0 |
| An American Sympathiser ... ... ... ... ... | 25 | 0 | 0 |
| Lady Shelley-Rolls ... ... ... ... ... ... | 25 | 0 | 0 |
| Flight Lieut. A. H. Wann ... ... ... ... ... | 20 | 0 | 0 |
| Mrs. E. M. Hilder ... ... ... ... ... ... ... | 10 | 10 | 0 |
| H. P. Marsh, Esq., J.P. ... ... ... ... ... ... | 10 | 10 | 0 |
| Staff of Royal Airship Works, Cardington ... ... ... | 10 | 10 | 0 |
| Lieut.-Col. W. Lockwood Marsh ... ... ... ... | 10 | 0 | 0 |
| Mrs. Waterlow ... ... ... ... ... ... ... | 10 | 0 | 0 |
| "From the Wreck" ... ... ... ... ... ... | 6 | 10 | 0 |
| Staff of U.S. Military Attaché ... ... ... ... ... | 6 | 0 | 0 |
| Lord Gorell ... ... ... ... ... ... ... ... | 5 | 5 | 0 |
| Mr. and Mrs. W. J. Anderson ... ... ... ... ... | 5 | 0 | 0 |
| Staff of U.S. Naval Attaché ... ... ... ... ... | 4 | 10 | 0 |
| Major C. C. Turner ... ... ... ... ... ... | 3 | 3 | 0 |
| Major G. H. Abell ... ... ... ... ... ... ... | 2 | 2 | 0 |
| Flight Lieut. F. M. Rope ... ... ... ... ... | 2 | 2 | 0 |
| Anonymous ... ... ... ... ... ... ... | 1 | 2 | 0 |
| Com. H. T. A. Bosanquet ... ... ... ... ... | 1 | 1 | 0 |
| Sir Charles Bright ... ... ... ... ... ... ... | 1 | 1 | 0 |
| "B. C." ... ... ... ... ... ... ... | 1 | 1 | 0 |
| E. R. Calthrop ... ... ... ... ... ... ... | 1 | 1 | 0 |
| Miss B. Haigh ... ... ... ... ... ... ... | 1 | 1 | 0 |
| Sir Samuel Roberts, M.P. ... ... ... ... ... | 1 | 1 | 0 |
| Major B. F. S. Baden-Powell ... ... ... ... ... | 1 | 1 | 0 |
| "J. T." ... ... ... ... ... ... ... ... | 0 | 10 | 0 |
| | £660 | 1 | 0 |

## Arrangements for the Month.

Nov. 3, 5.30 p.m. Lecture by Squadron Leader R. M. Hill, M.C., A.F.C., on "The Manœuvres of Getting Off and Landing," Royal Society of Arts, Adelphi, London.

,, 10, 7.0 p.m. Students' Discussion Meeting, W. L. Le Page on "The Soaring Flight Problem," in the Society's Library.

,, 14, 8.0 p.m. *Scottish Branch.*—Lecture by Air-Marshal Sir H. M. Trenchard, Bart., K.C.B., D.S.O., A.D.C., on "The Auxiliary Air Force," Institute of Shipbuilders and Engineers, Glasgow.

,, 17, 5.30 p.m. Lecture by Colonel F. Searle on "The Requirements and Difficulties of Air Transport," Royal Society of Arts, Adelphi, London.

W. LOCKWOOD MARSH, *Secretary.*

# PROCEEDINGS.

## FIRST MEETING, 57th SESSION.

A meeting of the Society was held on Thursday, October 6th, in the Hall of the Royal Society of Arts, London.

Air Commodore H. R. M. BROOKE-POPHAM said he was acting in a dual capacity, partly as Chairman of the meeting and partly as Lecturer. There was one pleasant announcement he had to make, and that was that Lieutenant-Colonel O'Gorman had been unanimously elected by the Council of the Society as Chairman for the ensuing year, commencing October 1st, and that he had accepted. He was sure they could not have a better choice than Colonel O'Gorman, on account of his long experience in aeronautics, his wide knowledge of scientific matters generally and also his charm of manner when he was Chairman of any meeting or committee. He would like to draw the attention of those present to a letter that had appeared in many of the daily papers on the previous Saturday on the subject of an airship memorial fund, called the R.38 Memorial Fund. The objects were pretty clearly set out in the letter, the point being to try and raise a fund for the continuation of research into airship problems, on however small a scale. There was no form of memorial that would have been desired more by those who had lost their lives in R.38 and previous airships than one of this kind, and he hoped they would be able to make it one worthy of them.

He would now take two paces to the right and become a lecturer.

Some months ago the Council had drawn up a beautiful series of lectures for the session, in which, to the relief of himself, and doubtless many others, his name did not appear, but whilst he was in a state of physical collapse, as a result of visiting tropical climates in the hot weather, he received a note from the Secretary saying the lecturer for that date had deserted, and that being unable to find anyone else he had to fall back on him.

Air Commodore BROOKE-POPHAM then delivered the following lecture :—

## AEROPLANES IN TROPICAL COUNTRIES.

1. I have recently paid a visit to Egypt and Mesopotamia with the object of finding out the particular troubles that are experienced with aeroplanes and engines in tropical climates. My stay in those countries only lasted for a total of 4½ weeks in July and August, and that, of course, is quite an insufficient time to get complete knowledge of the subject. In many cases I am afraid the information I shall give will be somewhat indefinite, but my main object is to indicate the troubles and leave their solution to other people.

2. First as regards the climatic conditions. The general impression I got was that, as regards the effect on aircraft materials, Mesopotamia was very nearly as much worse than Egypt as Egypt is than England, so that although one may get a solution for a particular difficulty in Egypt, it does not necessarily follow that the same solution will get over the difficulty in Mesopotamia.

At the end of the lecture are a few tables. No. I. shows the mean daily maximum and minimum temperatures for Cairo and Alexandria in Egypt.

No. II. gives figures indicating the relative humidity at London and Cairo, and you will notice the great variation at Cairo at different times of the day.

Table III. gives some figures for temperature and relative humidity at Bagdad, taken over an average of 30 years. You will see the differences in temperature are much higher than at Cairo, and they are somewhat trying to personnel as well as to material.

The figures for humidity cannot, I am afraid, be compared exactly with those given for Cairo, as they are taken one hour later, but there is no doubt that in the summer Bagdad is much drier than Cairo.

Table IV. gives some temperatures inside different types of building for various times of the day on July 21st, which was an unusually cool day.

The decrease in density of the air at Bagdad at midday in summer is roughly equivalent to starting at a height of 4,000 feet instead of at sea level, and in the case of most machines it means an increase of about 6 per cent. in the landing speed.

I did not do a great deal of flying, but so far as my experience went the eddy currents, etc., in the middle of the day were in no way so violent as to make flying dangerous, or even difficult for an experienced pilot, and I have certainly had far worse bumps during bad rain storms both in England and in France than when flying in Mesopotamia in the middle of the day.

This, of course, presupposes that one does not fly into a dust storm. These must be horrible, and the trouble is that they go up to very great heights in Mesopotamia, certainly over 12,000ft. at times.

Another thing that is disconcerting is the sudden changes of wind direction that one gets in the desert. On one occasion just after midday the wind, which was about 10 m.p.h. on the ground, kept changing 90 degrees in a few seconds, viz., from East to North and back again, and the smoke from a smoke bomb which was put out to give a guide to an unfortunate aeroplane trying to land, covered a segment of approximately 90 degrees instead of blowing in a straight line. About two hours later the wind suddenly died down completely, and five minutes afterwards began to blow steadily from a point a little south of West. One also gets sudden gusts, I suppose due to a small eddy; these are also liable to cause landing troubles.

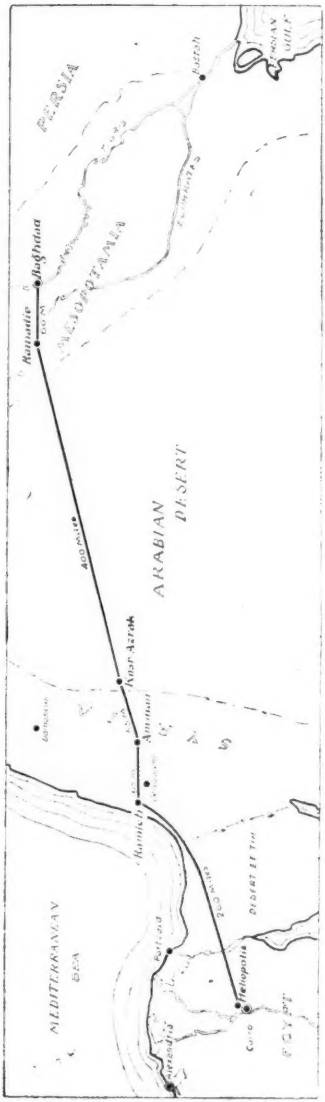
According to the records, whenever there is any wind at Bagdad it is nearly always from the North or North-West.

3. With regard to the aerodromes in Mesopotamia, they are certainly large, but they are in no way ideal. Most of them are dusty and many of them are covered with small stones. I did not find any real sand aerodromes where the sand was such as to render a machine liable to turn up on its nose. With regard to the stones, the chief trouble is, of course, that they get picked up by the propeller and cause damage, but they also mean excessive wear on tail skids. With regard to dust, this is unpleasant and may cause some difficulties when three or more machines are going off on a flight together, because very often the first one makes such a dust that the remainder cannot get off for some considerable time. This can be avoided to some extent by making all machines taxy down to the end of the aerodrome whence they are going to start off before the first one gets up into the air.

4. The chief troubles I came across may be divided under six headings:—

Timber Shrinkage.
Propellers.
Tyres.
Shock Absorber.
Petrol Supply.
Hangars.

5. With regard to timber shrinkage, I feel that this is a nuisance but not a danger. It is, of course, due to the humidity in the East being different to what it is in England.


PERSIA
Basrah
Baghdad
Rutbah
MESOPOTAMIA
ARABIAN
DESERT
Amman
Ramleh
Heliopolis
MEDITERRANEAN
SEA

Timber undoubtedly does shrink when it arrives in Egypt or at Bagdad, but in the former case a definite limit is reached in about two months, after which no further shrinkage occurs, and once the necessary adjustments are made to allow for this, no further difficulties are experienced from this cause.

There must also be a definite limit to the amount of shrinkage in Mesopotamia, otherwise one would have the finest conjuring trick on record, but I have no definite figures as to when this limit is reached.

Certainly in Egypt there is no sign that the timber swells again in the cold weather. As regards Mesopotamia, all I can say is that I could get no evidence to show that any reswelling occurs.

Of course there are various solutions to this shrinkage trouble; *e.g.*, to send out components and build up the machines in the country or to manufacture machines out there from timber that has been locally seasoned, but there is certainly no great difficulty in sending out machines in cases ready assembled. A point to be borne in mind is that metal fittings, especially where they clip completely round a wood member, should be adjustable, and it is also advisable to send out wings in an uncovered condition, because as a rule the planes have to be opened and the fabric stripped off a considerable portion of them in order to tighten up bolts and adjust the fittings generally. From tests that have been made, it does not appear practicable to dry-out timber to tropical humidity in this country and then to build up machines here of this timber. There is difficulty in the drying to begin with, then no varnish can be used that will be vapour proof as distinct from merely waterproof, so that the timber would very quickly get back to the English humidity standard again, and would be no better off.

So long as a machine has to fly merely in Egypt and Mesopotamia there is no necessity to make them all metal, but I still believe that when machines fly constantly from London to Bombay and back it will be necessary to do away with wood in their structure.

I saw one or two cases of laminated spars sent out as spares which had arrived with very ugly cracks in them. It is possible that this may have been due to unequal shrinkage of the two laminæ. Thin three-ply is inclined to blister and to come apart in the laminations. Thicker three-ply stands up fairly well, but causes a certain amount of trouble on a new machine owing to shrinkage.

6. As regards propellers, the wastage of these is high. There are two causes of wastage. First, splitting along the laminations or else actually cracking through the timber of the propeller, generally at the boss.

Secondly, damage to the leading edge of the blade by sand, small stones, or scrub.

The first trouble varies very much with the type of machine. Some of it, I think, has been due to the use of material that has been out in the East a very long time, *i.e.*, three or four years, and it may also be caused by the unequal shrinkage of different laminæ, which naturally must put an enormous strain on the material. I think it may be that the propellers that have given trouble are those with a somewhat low factor of safety, and that when wooden propellers are going to be used in tropical climates it will be necessary to make them somewhat stronger than would be necessary for England.

In some instances new propellers have actually been found to be cracked through the timber or split along the laminations when the box containing them was opened and before they were ever put on a machine.

As regards damage to the leading edge of propellers, the obvious remedy is to cover them with metal, but for use on some aerodromes, such as those round Cairo, very strong metal is required, and thin brass commonly used wears through in from 10 to 15 hours' flying. This metal, by the way, should extend all along the leading edge of the blade and not be limited to the propeller tip.

Metal propellers would afford a complete solution, but I see no reason to suppose that wooden propellers must be condemned for use in tropical climates, and I think a great improvement would be found if propellers were manufactured locally.

7. Tyres must form a large item in the upkeep of machines in tropical climates. There appear to be three sources of trouble: First, deterioration of the rubber of the tyre itself; secondly, deterioration of the valve; thirdly, punctures.

As regards the first, I think again that a good deal of the trouble experienced up to the present has been due to the use of old tyres which have not been stored under the most favourable conditions. There is, however, no doubt that rubber does deteriorate more rapidly in Mesopotamia than it does in England.

As regards valves, I think the solution to this difficulty will be found in the use of an all-metal valve, and we are already carrying out some experiments with this.

As regards punctures, this is due to camel thorn. The thorn that seems to do most of the damage is not very long, perhaps about $\frac{3}{4}$in., but it is very hard and sharp. A tyre seems to have a peculiar fascination for these thorns, and a tyre that has been run over camel thorn feels the same as one's chin does if one hasn't shaved for a couple of days. Some of these numberless thorns get forced through the outer cover and cause a puncture, even though they may not have been originally long enough to have reached the inner tube. I don't think any practicable thickness of rubber will get over this trouble, although it may be noted that D.H.10 tyres, which are 1100 by 220, do not appear to suffer much from the effects of camel thorn, whereas the next size tyre, 900 by 200, does suffer. What one does want is a tyre that is definitely impermeable to camel thorn. Rapson tyres are very successful on the one car that was fitted with them when crossing the desert, but I am afraid the weight of this would be prohibitive. As an instance of tyre trouble, I might remark that when flying over to Bagdad it was necessary to come down on a landing ground that was covered with camel thorn. The Vickers Vimy that was with me punctured one tyre on landing, and this was replaced by a spare wheel carried in the machine. It got off, and on coming down on the next landing ground it was found that three tyres were flat. Having no more spare tyres, the only thing to do was to deflate the fourth one and get off on four flat tyres. This was done successfully, and the machine landed at Bagdad with all four tyres flat. No damage was done to the machine, but the tyres were ruined.

The right solution to my mind is to do away with the need for pneumatic tyres altogether by improvements to undercarriages.

A minor point, but one which probably causes some of the trouble, is flat tyres. There seems rather a tendency in the East not to blow up a tyre too tight because of the belief that the air will expand and burst the tyre when it gets hot. I believe this is a fallacy, but the proper blowing-up of aeroplane tyres is a point to be watched, and to assist this a good form of tyre gauge would be most valuable.

In most cases it has been found desirable to use larger tyres than what was standard during the war; *e.g.*, 800 by 150 instead of 750 by 125 for a D.H.9A.

8. Shock absorbers frequently break in the East. Again, I feel this is largely due to the use of rubber shock absorber that has been in store a very long time or that has been kept under bad conditions. A broken shock absorber may lead to a wrecked aeroplane. One solution is to make use of coiled wire, like the Germans did during the war, in place of rubber. I am told there are difficulties in this, but if the Germans did it, I am quite certain that we can. But what one does want is some form of undercarriage that will do away with the need for rubber shock absorber as well as with the need for pneumatic tyres.

Where rubber shock absorber is used a guard loop of cable should also be put over it, so as to support the weight of the machine if the rubber gives way.

9. An item that may cause an unexpected increase in expenditure of any civilian service in the East is petrol, the wastage of which is apt to be very heavy. I came to the conclusion that the chief cause of wastage is the use of a fragile type of container. The type now in use holds four gallons and is much weaker than the standard two-gallon tin in use in England. Petrol tins are always apt to be handled roughly, and this is especially so with natives in the East. Petrol will ooze through a very minute crack, and although this leakage may be visible in England, it will quite likely pass undetected in a tropical climate, owing to the more rapid rate of evaporation. Again, minute cracks may be caused by internal vapour pressure as well as by rough handling. Also leakage through stoppers will be more rapid than in a temperate climate. It is possible that bulk storage would get over all this, but it would in any case frequently be necessary to use small tins, *i.e.*, up to five or six gallons, and it is very important that these tins shall be of stout construction. The screw stopper should be fitted with a really suitable washer, and it also ought to be covered with a soldered cap. This cap, however, must not be soldered down too firmly, otherwise mechanics are apt to damage the tin in taking it off. It must just be firm enough to be airtight, and that is all.

There is another source of wastage of petrol, though this is not a peculiarity of tropical climates, which occurs when filling up aeroplanes away from an aerodrome. In many machines the petrol tank is very hard to get at, and unless one has a ladder or a pair of steps, the man who is filling up has to get into a very awkward position where he cannot hold the tin steady, with the result that a large proportion splashes over and is wasted and also a considerable amount gets blown away by any wind there may happen to be. I may remark that in the Arabian desert there generally seems to be a wind of about 10 miles an hour on the ground.

Years ago we used to make use of a petrol pourer which would screw into the tin in place of the cap. It really consisted of two tubes, one for letting out the petrol and one for letting in the air. The use of these dropped out during the war. I really don't know why, but I am sure they would be very useful in Mesopotamia. Their use will, of course, necessitate having the tin with a screw stopper and not merely a soldered tin.

10. The upkeep of aeroplane hangars is another very heavy source of expense, mainly for the reason that the canvas covers in Mesopotamia are practically useless after one hot season. Experiments have been tried with regard to placing corrugated iron on the Bessoneau frameworks, and these appear to be quite successful. The chief point to be borne in mind is that no bolts or nails must be driven into the existing framework, otherwise it will not be strong enough to take the corrugated iron. It would appear that the existing frameworks are strong enough except in places exposed to very heavy winds, provided some form of U bolt is used.

11. The fabric on aeroplanes used to cause a considerable amount of trouble owing to rapid deterioration, but I consider this has really been solved by the use of the coloured varnish known as P.C.12 in conjunction with the aluminium varnish known as V.84 on top. The object of the P.C.12, of course, is to prevent the actinic action of the ultra-violet rays on the dope and fabric, while the V.84 reflects the heat rays of the sun and keeps the interior of the planes comparatively cool.

I saw a Bristol Fighter covered with P.C.12 and V.84 which had then flown for 164 hours. The planes were in very good condition, except where the castor oil from the engine had made them rather soggy.

Petrol-resisting tubing of the rubber type, of course, gives trouble in the East, but I don't think much worse than that in England. If the experiments now going on prove that all-metal tubing can be used, then this trouble may also be considered as solved.

The most important point about petrol-resisting tubing is to prevent deterioration in storage by keeping both light and heat away from it. The most effective

means of ensuring this is to store the tubing under water, taking adequate precautions to ensure that the ends of the tubing are kept dry, as otherwise the water will rot the internal canvas plys. One method suggested is to keep the ends of the tubing about 3ins. above the surface of the water and to seal the ends with paraffin wax.

I mentioned previously that tail skids wear very badly on the stony aerodromes of the Middle East. The most effective remedy for this is to fit a detachable rubbing shoe of some hard steel, replacing it as soon as it gets worn through.

Thick triplex glass is bad in the East, as it very soon becomes opaque, but the thin triplex glass as used for goggles does not give trouble of this nature. It is, by the way, very important for pilots to wear tinted goggles, at any rate when flying in the summer, otherwise their eyes are apt to get seriously affected by the sun.

The tail adjusting gear of aeroplanes is liable to suffer damage on account of the dust. The fuselage covering should enclose it completely, and some form of inspection door be provided. On one or two machines holes are left in the fuselage cover to facilitate inspection, such holes ought not to be left open but be fitted with some form of removable cover.

A much-felt want is a good petrol gauge for telling the pilot how much petrol he has left in his tanks. This has been needed as long as I can remember, but very few machines are fitted with one. Sometimes a glass panel is provided in the tank itself, which under favourable conditions can be seen though seldom read by an agile pilot, but what is wanted is some indicator on the instrument board.

Insects in Egypt and Mesopotamia do not attack any part of aeroplanes, but concentrate their efforts on human beings.

12. Now as regards the engines. I could not find any trouble specially due to the climate either in Egypt or Mesopotamia. Of course for most machines an additional radiating surface is necessary; for instance, on the D.H.9A the size of the standard radiator is 6.65 sq. ft., and an auxiliary radiator has to be fitted with an area of 2.5 sq. ft.; on the Bristol Fighter the sizes are, main radiator area 4.1 sq. ft., auxiliary radiator 1.54 sq. ft. With these radiators the water can be kept well below boiling even in the middle of the day.

The most important thing, as most people know, is to prevent the water beginning to boil. Once it has started, it is very difficult to stop. On one occasion I made my pilot take off a machine not fitted with extra radiators at 4 p.m. in the middle of the desert. Both the engines started to boil before we got off the ground, and by the time we got into the air we resembled a locomotive. We had to give it up after about ten minutes, and during that time lost 10 gallons of water out of the 16 in the whole system. Making up 10 gallons is rather a serious problem when you are carrying nothing but drinking water, with the next well 120 miles ahead. During some experiments carried out at Martlesham on this subject, it was found that 72 per cent. of the total water in the system could be lost in three minutes. It is therefore very important to keep a close eye on one's radiator thermometer in the tropics and not to do foolish things, such as leaving one's radiator shutters closed by mistake.

Fitting an auxiliary radiator is much preferable to merely enlarging the size of the standard radiator, because in the cold weather the raditaing surface is too large with the extra radiator, and the latter can then be taken off, thus reducing the head resistance.

Oil radiators have been tried, but have been abandoned as useless and unnecessary. I think it is pretty definite that oil temperatures depend entirely upon the water temperature, and so long as this is kept down there will be no serious trouble with regard to the oil.

Dust appears to give no trouble to engines, except when they are taken down

for overhaul. Great care must be taken that the shop where the engines are being taken down is as dustproof as possible. It is necessary to have double doors, double windows are a great advantage, and in order to allow for closing the windows, some form of forced ventilation is required.

Sparking plugs and magnetos give no particular trouble.

13. There are one or two points about packing. First as regards engines, it seems very hard to prevent these getting rusty on their way out. It is no good, of course, trying to send out engines installed in the fuselage, at any rate in the case of tractor machines, partly because the fuselage is apt to get damaged and also because it is very difficult to get a large case airtight. I believe engines going out to the East ought to be packed in a special dry room, so that the air that is actually enclosed inside the tin-lined and soldered case will not contain any moisture that might cause damage.

One other point. Machines are generally sent out without their wheels, and in some cases shock absorber is wound on the axle and machines sent out with it on. This is a mistake, as the machine is apt to get dragged along on the floor of the packing case, and so the shock absorber gets practically ruined and has to be replaced.

As I mentioned before, I think it is an economy to send out wings in an uncovered state.

14. Perhaps some remarks about the cross-desert route from Cairo to Bagdad may be of some interest. I might say that I had nothing whatever to do with the making of this route, but have merely been over it like a sort of Cook's tourist. The main objects in starting it were first to have the means of supplying Mesopotamia with aeroplanes by air from Egypt, instead of sending them round in cases *via* the Red Sea and the Persian Gulf; secondly, to form the first stage of the air route from Cairo to India and Australia; and thirdly, to establish the means of quick communication between Mesopotamia and Cairo, and so with England. Normally, a letter going from London to Bagdad travels *via* the Suez Canal, the Red Sea, Bombay, Karachi, the Persian Gulf and Basra, and takes between five and six weeks, thus making Mesopotamia, from the point of view of communication, one of the furthest outposts of the Empire. The air route can and is actually altering all this. I have seen in Bagdad a London paper only nine days old. A pilot has arrived in Bagdad 8½ hours after leaving Cairo, and an officer has arrived in London 6½ days after leaving Bagdad.

From very ancient days a caravan route has existed between Damascus and the Euphrates, running practically due east of the former. There is water on this route, whereas to the south of it, where the desert air route now runs, there is practically none. The question then arises, Why fly across the southern part of the desert instead of continuing to follow the caravan route, as has been done on several occasions? The reason for that lies in the fact that under the Peace Treaty the northern boundary of our zone of influence comes a long way south of Damascus and cuts the old caravan route about halfway across. We cannot fly military aeroplanes over other people's zone of influence.

15. With regard to the nature of the country, the word "desert" is somewhat of a misnomer. It is not a sandy desert at all, but rather a steppe, which would probably be very fertile if there were more water. The surface is quite hard, and in many places is covered, or partially covered, with a sort of scrub, which is, of course, all dried up in the summer. It rains, I believe, for about one week in the year, and after that there is a large amount of grazing for camels. The desert lies high, being nearly all over 2,000ft. above the sea, in some places well over 3,000ft. Over a height of about 1,000ft. above the surface there appears to be a permanent westerly wind.

16. The desert is uninhabited as we should understand it, although after the rains a good many nomad Arabs wander over it, grazing their camels. Even

then, as I said before, there is practically no water, except occasional surface water, but the camel food that grows at that period of the year is very succulent, so that the camels do not want to drink. The attendants live on camels' milk. They drink water when they can, but this is reserved chiefly for their women and children. I believe that they sometimes go for as long as two or three months drinking nothing but camels' milk.

Even in the summer there will be an occasional raid across the desert. The object of these is to steal someone else's camels. The raids are generally carried out according to strict rules. For instance, it is very wrong for a raiding party to kill any individual of the tribe whom they are raiding, although the raided tribe may defend themselves. When a man is killed a blood feud is started, but can be cancelled by adequate compensation. The current rate of exchange is 40 camels per man. Again, if the raiders get off with camels belonging to a widow, she can run after them and, using the proper formula, say she is a widow, and demand her camels back. I am told that this is generally done. One of the political officers told me that he was talking to a Sheik and told him that raids were forbidden by the British, and asked why did they still go on doing it, pointing out that Englishmen never raided each other. The Sheik thought for a moment and then said: "Yes, but you play football."

17. The first Air Force party to be sent across this desert was the car convoy. The object of this was partly to select possible landing grounds, but chiefly to make a definite track across the desert which aeroplanes would follow. I have sometimes seen some criticisms of this track, and people say why don't we fly straight across? Well, from the point of view of pure flying this would be the simplest thing to do, and if one did get a few degrees out of one's course one would simply go on until one met the Euphrates; but unfortunately, in this year of grace 1921, one cannot guarantee against engine failure in some form or other. If an aeroplane comes down in the middle of this vast desert it is exceedingly difficult to find, even if it is fitted with wireless, the result being that if there were no form of track we should be bound sooner or later to lose pilots. However, so long as one has got a track, and the aeroplanes follow it, a machine having a forced landing would be bound to be picked up, because even if the wireless did break down, rescue parties would be sent out within 24 hours from each end and they would follow along the track until they saw the damaged machine. Then steps would be taken either to drop water or other supplies, to land in the vicinity or help in some other manner.

Up to June 25th of this year no European, so far as is known, had ever crossed this part of the desert from east to west, or vice versa. People have, of course, been along the caravan route to the north, and others, such as Miss Gertrude Bell, Mosil and Colonel Leachman, had wandered over a large part of the desert, but mainly in a direction of north and south. It was, therefore, somewhat of a bold conception to decide to send off a small party to cross this unknown desert. The fact that it was accomplished successfully, I think, reflects great credit on those responsible for its initiation and organisation, as well as the actual performers. The car party had many difficulties to contend with, especially during the first part, where a passage through lava had to be found. Final success was due chiefly to effective co-operation between aeroplanes and the cars, the former reconnoitring the route and bringing out supplies from Amman. On the outward journey six Crossley light tenders and three Rolls-Royce cars belonging to the Machine Gun Corps, were taken; all bar one vehicle have now done the complete journey to Bagdad and back.

18. A great many experiments were carried out as to the best method of marking the route, but it was eventually found that the wheel tracks of the cars themselves were sufficient in most places, each vehicle following closely in the tracks of the preceding ones. Over certain portions of the route it was necessary to use a sort of wide shallow plough, and this was also used to make arrows by the

side of the track occasionally. I don't suppose a car track of this nature would be of much value in a sandy desert, but it is certainly most effective between Amman and the Euphrates, and there is no real difficulty in following it from the air. One has to use one's brain a little bit, *i.e.*, sometimes one has to look two or three miles ahead and sometimes one has to look almost vertically downwards. From the pilot's point of view there is a great advantage in having a continuous line of this nature to follow, instead of occasional marks such as bomb craters, and it is rather fascinating to watch the little narrow line stretching away in the distance, the one thread linking you not only to civilisation but to food and water.

19. Before this car party started the maps of that part of the world observed a discreet blankness, but now the route followed by the cars and some of the prominent points near it have been accurately fixed by surveyors. They made use of the stars for fixing their position at night accurately and this method entails knowing the exact time. The chief surveyor took a small wireless set with him and every night about half-past ten used to set it up and listen for the time signals from the Eiffel Tower, and this checked his chronometer to a tenth of a second. There is something rather romantic about this, the operator in the centre of a great city working his sending key and, all unknown to himself, enabling some stranger over 2,000 miles away to locate his position in a trackless desert.

20. Now as regards the journey itself. I won't say anything about the part from Cairo to Amman because many people know that part of the world. However, here is a slide (not printed) showing the officers' mess at one of our aerodromes, not far from Jerusalem, consisting, you see, chiefly of aeroplane cases. This is just to show that the Air Force are not spending a large amount of the public's money on permanent buildings, but endeavouring to be economical. The Dead Sea looks quite pretty from the air and quite reminded me of the Italian lakes; but the Jordan, at any rate in the summer, is disappointing, being a miserable, dirty little ripple, in fact I quite sympathised with Naaman in not wishing to bathe in it.

Amman is a town with about 12,000 inhabitants, including a great many Circassians who were originally sent there by the Turks to keep control over the Arabs. In old days it used to be the headquarters of a Roman legion. There are still remains of a Roman amphitheatre and of one or two temples, and when you go down to a bazaar in Amman you will probably find yourself on a stone which, when examined, is seen to be the capitol or base of a Roman filler. Amman is at present the capital of Trans-Jordania, and Abdul, king of that part of the world, has his court in a big camp at Amman. The aerodrome here is very dusty, about 2,700 feet above the sea, and has higher ground around. It is an unpleasant aerodrome to get off from in a slow-climbing machine.

The first point out from Amman is Azrak. There is no village or anything there but water springs, which form a series of pools in the summer and a lake in the winter. The ground immediately round these pools is fertile and the place forms rather a centre for nomads. The Romans had a fort here, the foundations of which are still to be seen, and the Persians built a castle, the ruins of which are still left. The water is beautifully clear and quite good to drink.

From Amman to Azrak the country is undulating and bare, in fact one may say the desert begins a few miles east of Amman. At Azrak one begins to get into the first part of the lava country. There are masses of this lava about, but so far as is known there is no volcano. The lava appears to have welled up out of the earth through a sort of crevasse and merely flooded over the whole countryside. The Persian castle and the old Roman fort I referred to are built of lava.

From Azrak onwards one also comes across what are called mud flats. These are large areas of a sort of light yellow soil which looks white and almost dazzling in the sun. They are perfectly level and smooth, nothing grows on them, and some of them are several square miles in extent. In many ways they form an absolutely ideal aerodrome, the only drawback being that they are so smooth and

level that it is very difficult to judge one's height; in fact it is like alighting on a perfectly smooth sea. The best plan is to come down quite low over the edge and land just beyond it. The surface is quite hard, and though it is cut into by tail skids, is but little affected by aeroplane wheels. These mud flats are probably formed of the matter which is carried down in suspension by streams during the rains. It seems probable that they are covered with water during the rainy season; in fact one or two were still wet in July.

I spent a night on one of these mud flats owing to the fact that one of three machines in my flight had to land on account of engine trouble.

This formed another instance of the value of wireless in the desert. The machine that had engine trouble sent out a wireless message to say it would be forced to land. That was taken down in my machine and the message handed to me and at the same time it was being received at Bagdad and Amman, and from the last transmitted to Cairo. So in a few minutes there was I up in the middle of the air over the desert, Bagdad and Cairo, all knowing that this particular machine was having to land and why.

After a bit of fairly open steppe country one then comes to the second lava outcrop about 120 miles from Amman. The lava here is much more continuous than it is close to Azrak, and it was here that the car convoy met with their greatest difficulties. It is a most depressing area of country to fly over, and it has quite a bad effect upon one's nerves, at any rate some people's. I know I felt as if the end of the world had really come and there was no one left alive except my pilot and myself, and that the sooner we joined the rest the better. The lava ends just before landing ground F, and from there practically till one reaches the Euphrates, the country is open steppe. A peculiar thing about this lava country is that there are traces of some ancient civilisation on it. There are several circles of lava blocks which may very likely be the remains of houses, but in addition there are straight walls, which from the air look like the boundaries between fields, in fact they are not unike an open stone wall country in England, such as that round Cirencester. I noticed these walls principally on the eastern edge of the lava.

El Djid is a sort of half way place between Amman and Bagdad, and one constantly sees it referred to. It is marked on many maps; in fact some people think that there is a large village, and even a town there. This slide (not printed) shows what El Djid really consists of—simply a well. There are actually two wells there, one of them about 160ft. deep bored through solid limestone; who made it I don't know. The water tastes very good.

21. On the occasion that I crossed the desert to Bagdad there was quite a gathering at El Djid. There was the R.A.F. car convoy returning from the east, another car convoy, which had been reconnoitring for a railway, came down from the north, and my flight of three aeroplanes from the west, three independent parties all meeting at this poor little well in the midst of the vast uncharted desert. On this particular occasion the party that came down from the north told me that they had come across a Sheik who had been wounded two days before in the course of a raid made on him, and suggested that, as this Sheik had been friendly to the R.A.F. convoy at the time it was moving to Bagdad, it would be a good thing to fly him to Bagdad for hospital treatment. This was referred by wireless to Sir Percy Cox in Bagdad, who agreed, and so we decided to do it. A couple of Ford cars were sent off to pick up the Sheik and take him to the landing ground known as L.G.4A. About four hours later I started off with three machines, and just as we got over L.G.4A we saw two little black dots hurrying along over the desert, these being the two Ford cars with the wounded Sheik and a friend of his. We landed all right, put the Sheik into one of our machines, the Vickers-Vimy, and eventually got him to Bagdad in safety. What the Sheik thought of it I do not know; poor man, he was not given much of a chance to

object. Hustled first into a Ford car, then out of that into this strange-looking contraption of wood and canvas, borne for hundreds of miles through the air, lifted into an ambulance, and before he knew what was actually occurring he was lying on a bed in Bagdad hospital and being X-rayed. Somewhat alarming for a wild sort of child of nature, who had probably never slept in a house in his life. There was a rather interesting sequel to this; a few days later one of our machines landing at El Djid to fill up with petrol was damaged. A flight of six more machines were sent out from Bagdad to take out spares and mechanics to repair it, and the whole party had to spend the night at El Djid. Just about sunset they saw five men on camels ride up and proceed to take up an outpost line round them. These five men remained thus on guard all through the night, and at dawn mounted their camels and rode silently away. It was found later that these were five men from our wounded Sheik's tribe who, learning that the Air Force were in some trouble, had taken steps to ensure that they were not molested during the night. The Sheik has recovered and is now back with his tribe.

There appears to be a sort of natural fellow-feeling between these nomad Arabs and the Air Force. Perhaps both feel that they are at times in conflict with the vast elemental forces of nature, forces which could completely overwhelm them at any moment, were it not for the fact that nature is on the whole tolerant to such puny little creatures as human beings. I came across a case of the same sort of friendly feeling occurring in the Sinai Desert.

22. In the country between the Euphrates and the Tigris there are traces of the old civilisation, chiefly in the way of canals, which are now dry. Nearly all the existing cultivation in that area lies close by the banks of the two rivers, and between them is practically a desert. So far as I can make out there is not much point in building canals at present in this part of the world, because if one did put more land under cultivation there is no labour to work it. One cannot import labour partly because the climate is unsuitable and partly because the Arabs won't have it, so if one wants to make Mesopotamia prosperous the only thing to do is to reduce the infantile mortality, which I believe at present amounts to as much as 70 per cent.

Bagdad is a disappointing place, at any rate approaching it from the air, being simply a glorified mud village and hardly distinguishable at evening from the desert.

23. As regards the equipment to be carried by machines in the desert, there are certain things that are essential:—First, a supply of water and food for every individual. At present the military machines carry five gallons of water and ten days' rations per head. The rations by the way want to be suitable for the desert; bully beef and Army biscuits are not very appetising; but things like dates, tinned fish, if it hasn't gone bad, and some form of thin biscuit, are what is wanted, specially dates. Then as regards the machines. Always take at least one spare wheel, some Very's lights, smoke flares for dropping from the machine to give wind direction on the ground, signalling strips for making signals to a rescue party in case one has trouble, picketing gear for the machine, propeller covers, a few small tools and weapons of some sort. A small medical companion is also desirable, and this should consist not merely of bandages, but contain a few of those medicines that one does want in the East, *e.g.*, permanganate of potash for water, phenacetin and chlorodyne. Picketing gear is most important in the desert because you never know when a sudden gust will not come up, and they are sometimes so violent as to upset a Handley Page. It ought to be a recognised routine that before anything else, when a machine is landed in the desert, the machine must be properly pegged down.

24. It is very important that a machine crossing this desert should be able to fly the whole way across, or at any rate between Ramadi and Amman, without

having to fill up with petrol. At present, although a D.H.9A can fly from Amman to Bagdad, it cannot fly from Bagdad to Amman without refilling. This is of course on account of the permanent westerly wind. This means carrying petrol in tins, usually slung on under the lower planes, and then landing to fill the tank. Now a landing in the desert is apt to lead to trouble, largely on account of the vagaries of the wind. As a case in point, when Sir G. Salmond and I were flying back from Bagdad, we landed at El Djid to fill up with petrol. The first of the three machines to land damaged its undercarriage, not badly, but it couldn't get off as it stood. We decided to leave it there and proceed with the other two, after sending a wireless message to Bagdad to say what had occurred. Six machines had to be sent from Bagdad to bring out a spare undercarriage, tools, trestle, etc., and one of these six also damaged itself, in fact a good deal worse than the first machine. Well, if any attempt had been made to rescue that second machine I suppose 12 aeroplanes would have had to come out, and then two of those 12 would have crashed. However, the Officer Commanding Mesopotamia wisely decided to cut his losses, and made no attempt to get back the second damaged machine. To soothe our economists I might add that the engine and instruments were salved.

25. Now as regards the prospects of this desert route for civilian enterprise. My own opinion, which is probably quite valueless, is that it is not suitable for civilian traffic at the present time.

A journey across that desert is in the nature of a military operation. There is always a good sporting chance of trouble with somebody, of Arab raiders, and the first thing one does if one has to spend the night in the desert is to get one's machine-gun ready. However, once the whole country has settled down, I feel confident that there will be great openings for civil air services, and those interested cannot begin to study the subject too early. It was with the object of assisting this, that I ventured to give this so-called lecture to-day.

**TABLE I.**

MEAN DAILY MAX. AND MIN. TEMPERATURES.

| Month. | Cairo. | | Alexandria. | |
|---|---|---|---|---|
| | Max. | Min. | Max. | Min. |
| January ... | 77 | 36 | 73 | 44 |
| February ... | 79 | 39 | 75 | 43 |
| March... ... | 84 | 43 | 81 | 48 |
| April ... ... | 99 | 47 | 94 | 52 |
| May ... ... | 103 | 54 | 98 | 58 |
| June ... ... | 104 | 62 | 96 | 65 |
| July ... ... | 101 | 65 | 91 | 69 |
| August ... | 99 | 67 | 90 | 71 |
| September ... | 97 | 61 | 94 | 66 |
| October ... | 93 | 57 | 93 | 58 |
| November ... | 84 | 46 | 83 | 53 |
| December ... | 74 | 41 | 75 | 47 |

## TABLE II.

NORMAL RELATIVE HUMIDITY AT LONDON, CAIRO (HELWAN).

| | | Jan. | Feb. | Mar. | April. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| London | 07.00 hrs. | 87 | 85 | 86 | 84 | 81 | 80 | 81 | 85 | 89 | 91 | 90 | 87 | 85.5 |
| | 13.00 ,, | 80 | 75 | 68 | 62 | 61 | 60 | 59 | 61 | 65 | 73 | 79 | 82 | 68.79 |
| | 18.00 ,, | 84 | 80 | 74 | 66 | 63 | 62 | 61 | 65 | 73 | 83 | 86 | 86 | 73.58 |
| Cairo (Helwan) | 07.00 hrs. | 69 | 64 | 63 | 55 | 50 | 55 | 65 | 69 | 68 | 67 | 68 | 70 | 63.58 |
| | 13.00 ,, | 42 | 34 | 29 | 23 | 20 | 21 | 24 | 27 | 30 | 33 | 37 | 44 | 30.3 |
| | 18.00 ,, | 56 | 48 | 43 | 36 | 32 | 33 | 34 | 40 | 48 | 51 | 54 | 58 | 44.4 |

These figures for Helwan Aerodrome would be 10-20% higher, as these records are taken at Helwan Observatory on the hill, 115 metres high.

## TABLE III.

AVERAGES AND EXTREMES AT BAGDAD, 1888-1918.

Lat. 33 21′ N. Long. 44 × 26′ E.

| Month. | Mean. | TEMPERATURE. | | | | Relative Humidity at 8 a.m. | RAINFALL. | |
|---|---|---|---|---|---|---|---|---|
| | | Mean Monthly Extremes. | | Absolute Extremes. | | | | |
| | | Max. | Min. | Max. | Min. | | Amount. | Days. |
| January ... | 46.8 | 67.7 | 29.3 | 79.9 | 20.8 | 78 | 1.13 | 4.7 |
| February ... | 53.0 | 73.6 | 32.4 | 84.8 | 27.7 | 73 | 1.10 | 4.1 |
| March ... | 60.3 | 83.7 | 40.0 | 98.8 | 33.5 | 69 | 1.23 | 5.1 |
| April ... | 70.2 | 92.7 | 50.1 | 107.7 | 43.8 | 60 | 0.82 | 2.8 |
| May ... | 80.7 | 103.8 | 58.1 | 112.6 | 46.5 | 50 | 0.20 | 1.2 |
| June ... | 89.6 | 112.3 | 69.0 | 119.2 | 62.8 | 37 | 0.00 | 0.1 |
| July ... | 94.0 | 116.0 | 73.1 | 122.8 | 69.6 | 37 | 0.00 | 0 |
| August ... | 93.8 | 116.7 | 72.3 | 121.0 | 68.9 | 40 | 0.02 | 0.1 |
| September ... | 86.9 | 112.0 | 63.4 | 117.2 | 56.0 | 42 | 0.00 | 0.1 |
| October ... | 76.3 | 101.8 | 54.1 | 108.0 | 47.5 | 51 | 0.08 | 0.7 |
| November ... | 60.7 | 86.0 | 40.2 | 95.3 | 29.5 | 66 | 0.84 | 3.1 |
| December ... | 50.3 | 71.5 | 33.0 | 81.0 | 18.6 | 79 | 1.22 | 4.7 |
| Year ... | 71.9 | 94.8 | 51.4 | 122.8 | 18.6 | 57 | 6.64 | 27 |

**TABLE IV.**

TEMPERATURES INSIDE DIFFERENT BUILDINGS AT BAGDAD, 21st JULY, 1921.

| Time. | Men's Quarters. | Permanent Hangar. | Bessonneau Hangar. | Workshop with very high roof. |
|---|---|---|---|---|
| 0600 | 87 | 82 | 84 | 90 |
| 0800 | 93 | 93 | 96 | 95 |
| 1000 | 102 | 105 | 110 | 103 |
| 1200 | 103 | 110 | 121 | 107 |
| 1400 | 106 | 120 | 125 | 109 |
| 1600 | 108 | 123 | 124 | 110 |
| 1800 | 108 | 117 | 115 | 108 |

Maximum temperature inside an aeroplane case containing new machine ... 130°.
Maximum shade temperature in the open ... ... ... ... ... 116°.

## DISCUSSION.

Mr. F. Handley Page said they had heard an exceedingly interesting lecture, and it was also interesting to see all those pictures of a land which to most of them was entirely unknown and to realise the enormous number of different kinds of people who in different times of the world's history had crossed over the same parts of the world. Take Xenophon and the Ten Thousand marching over similar ground. What a different experience they would have had if the journey had been carried out as General Brooke-Popham had carried it out. One might also imagine Solomon flying over there and speculating on the way of an eagle (Mark VIII. Rolls) in the air.

More particularly from the point of view of the aircraft constructor, one wondered whether it would be a necessity that metal machines should be employed on those routes. He was not altogether convinced that their use would come very quickly. When one had wood spare parts could easily be carried or made on the spot, and wood had so much greater local strength than steel. If one had steel an enormous supply of spare parts must be carried to repair the wings with the special kind of material that was necessary for aircraft. So he was not altogether convinced yet that they had completely done away with wood for these big tropical temperatures. He would like to know from the Lecturer whether he thought it was an absolute necessity. When he (Mr. Handley Page) was over in the States this year he examined metal machines which had been in operation under service conditions on the postal service. There was first of all trouble with petrol tanks leaking. The petrol tanks being in the planes, the leakage caused gas to accumulate, with the result that the planes were blown off with the inevitable explosion that occurred after an engine back-fire. They had also had trouble with the metal covering of the planes corroding and being eaten away by electrolytic action, especially where those parts were heavily stressed. That simple little trouble seemed to be a considerable one from the point of view of keeping the machines in condition for flying. He would like to lay emphasis on that side of the question as being one which must not be overlooked when they were thinking of substituting metal for wood in very hot climates.

He would like to remark how exceedingly apposite it was to have a discussion on aeroplanes for tropical climates at the present time when we had a temperature of 84 degrees in the shade. They should all devote attention to the probable climate of this country next year, and if it were to be as hot as that of the season now ending those interested in the London and Paris service would do well to winter in Mesopotamia, so as to be ready for the coming season between London and Paris.

Brigadier-General CADDELL said that the romantic side appealed far more strongly to him than any other.

To have crossed in one day the four great rivers of history—the Nile, the Jordan, the Euphrates and the Tigris—was a most wonderful feat.

Looking back to the times when the famous cities of Nineveh, Babylon, were in existence, it was in 2000 B.C. that Sennacherib, whose name was made immortal by Byron, crossed the Tigris, Euphrates and Jordan, but his armies of 200,000 men were smitten by the Angel of the Lord on the borders of Egypt before he could reach the Nile.

Seventeen hundred years later Alexander crossed all four rivers, and if there were only a witch or wizard of Endor present who could raise him up, his experiences would be interesting to hear.

Dealing with the technical side, the speaker inquired if, in view of the success of the 90 h.p. R.A.F. engine in Egypt, steps could not be taken to develop a good air-cooled engine for use on the Cairo-Bagdad route.

From the commercial point of view the running of such a service was a difficult problem, though he felt it was capable of solution.

One of the main disadvantages was the supply of personel, as the white man would require high wages and would probably want a great deal of leave in such climates. The speaker asked if any developments had taken place in the scheme originated about May, 1918, by Vice-Marshal Sir Geoffrey Salmond for the instruction of the young Egyptian in technical matters.

As the Cairo-Bagdad service would soon be in regular operation the speaker suggested that commercial aviation would be materially assisted if the R.A.F. machines on this route were permitted to carry, up to a specified load, ordinary business letters.

Colonel W. D. BEATTY said that the Lecturer had brought out a very large number of points which were well worthy of attention by firms operating routes in these latitudes, as well as by those who contemplated operating in the Middle East.

Taking tyres, for instance, these give a good deal of trouble in England. During the war the Germans *had* to cut down their use as much as possible, though he must say that the samples of solid-tyred wheels which he had seen did not give him the impression that they had seriously tackled the problem. Why should we not try a pressed steel wheel with a steel tyre, arranging for all the shock-absorbing capacity to be provided in the oleo gear?

He felt sure that both constructors and users of aircraft would like to know the latest information regarding the very promising flexible metal joints—details of the design of which have recently been published. He believed he had seen figures somewhere showing that the majority of forced landings can be traced back to defects in the rubber connections at present used in the petrol system.

The trouble with Triplex glass, mentioned by the Lecturer, has been experienced in England during this last summer on motor cars.

He would like to emphasise the need, mentioned by the Lecturer, for a really good petrol gauge. Could not the designers of water and gas meters produce a meter which, calibrated during manufacture, and including a distant reading

gauge, could be fitted to any tank? It might be so arranged that the tank was both filled and emptied through the meter, and the pilot would know exactly what fuel he had at any moment.

In regard to oil temperature, is it really clear that oil radiators are not required? If his recollection were correct, the experience of the Martinsyde in the last Gordon-Bennett race pointed to the necessity for an oil cooler under certain conditions. He believed that the trouble with this machine was due to lack of oil pressure, the oil reaching and maintaining a state of boiling, and so remaining mainly foam, although the water temperature was reasonably low.

If any information had yet been compiled on the matter, it would be interesting to know whether the conditions experienced in practice at aerodromes situated at a considerable altitude are the same as might be foretold by calculation. For instance, did the run required to get off at Amman correspond with the calculated run based on the performance of the machine at sea level?

The question of prevailing winds is one which, as the Lecturer has shown, has an important bearing on the design of machines to be used on a given route, and it is a matter which is very liable to be overlooked when the operation of a new route is being considered.

The general impression he had received from this most interesting lecture was that new troubles need not be anticipated in operating routes in the countries in question, but that those troubles known in England will be met with in exaggerated forms.

At a forced landing in England, for instance, the local inhabitants may steal a watch, or provide a car for the pilot's convenience, while in Mesopotamia they may carry the idea so far as to steal the pilot's life, or provide him with a packet of dates to save him from starvation!

Major-General Sir W. BRANCKER: I don't quite agree with Air Commodore Brooke-Popham's remark that the Cairo to Bagdad route is unsuited for a commercial transport service at present. After all, the existence of pirates and privateers in the past was never used as a reason to confine seagoing activities to ships of war!

It is all very well to say that these services will be handed over to commercial control when the right time comes; human nature is strong, and no one likes the idea of reducing establishment, so that Government may cling to the control of the service for many years and thereby prevent progress on one of the most important air routes in the British Empire. There are certain Government aviation officials now whom the outside world consider useless, but who are longing to find something to "control" and so justify their existence.

We have seen sufficient of Government control in the past to justify a most earnest prayer that it will not be permitted to exert its baneful influence on aerial transport in the future.

Colonel H. T. TIZARD said he had an impression that the troubles to which the Lecturer called attention remained troubles longer than they need because the makers in this country did not hear of them to the extent which they might. For example, a good deal had been heard of the rubber troubles in the tropics, but nothing very definite. It was known that rubber deteriorated quickly there, but the causes still seemed to be uncertain. Until more definite information existed it was difficult to get improvement on the part of the industry. A great deal of good might be done by really reasoned technical reports from the big users of such materials in the tropics. If reports were only received from small users, they might concern isolated cases, and hence might possibly be misleading.

In reference to the water trouble with engines, he thought it was quite possible to use oil for cooling. An oil could be used which would circulate well at a temperature of 150 deg., which would be a long way below its flash-point.

The cylinder wall temperature of an air-cooled engine was a great deal higher than 150 deg. The use of oil would increase the efficiency of the radiator and prevent troubles to which the Lecturer referred. It should be possible to use an oil that boiled at 250 deg. and could be used satisfactorily in the cooling system of an engine at about 120 to 150 deg.; if so, there would be no sign of trouble due to boiling. The question was worth taking up more energetically.

One remark of the Lecturer's which the audience appreciated very much was that in regard to the assistance of wireless to men in the desert and to the general operations of aeroplanes out in the East. Wireless telegraphy was almost a supreme example of what could develop from the work of a few enthusiasts in a laboratory. In these days of urgent need for economy, it is well to remember the importance of pure research which to the sternly practical man may seem to be useless at the time.

Major-General Sir R. M. RUCK thanked the Lecturer very much for his excellent lecture, and he thought the Secretary should also be congratulated on his brilliant inspiration when, in the absence of anyone else, he told off the Chairman to give his lecture this afternoon. It had given them a lot of very interesting information which they could not have got in any other way. He would also like, on behalf of the members, to congratulate the Lecturer on the delightful manner in which he had presented the subject. Air Commodore Brooke-Popham was an old member of the Society and had been a very good friend to it both as a member and Chairman, and also in a high official capacity. He moved that he be accorded a very hearty vote of thanks.

In reply to a question by the Lecturer, Squadron Leader HILL said the Bristol Fighter had flown between 100 and 200 hours with all-metal petrol joints.

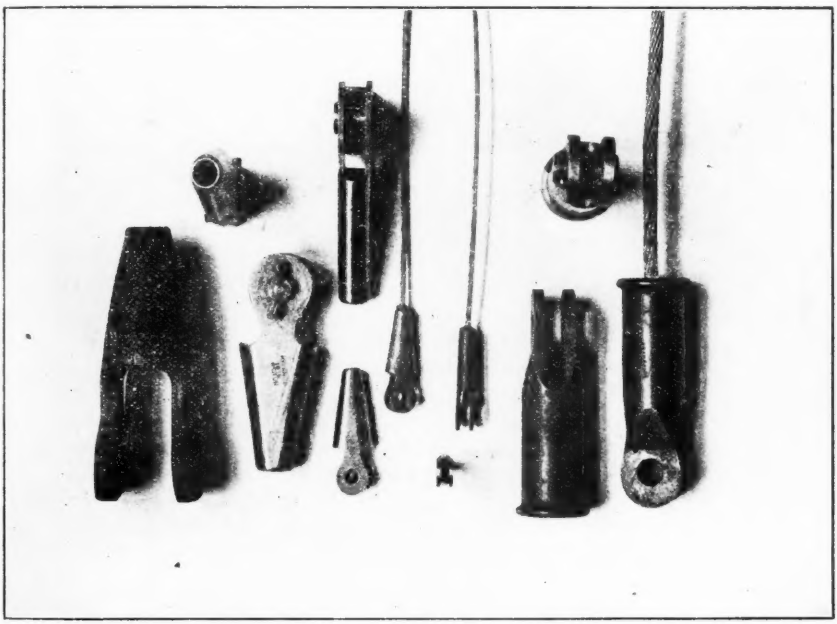
The LECTURER said they were doing a good deal of work with regard to air-cooled engines, although practically all the engines out in the Middle East now were water-cooled. There were advantages in the air-cooled engines, but they must be as reliable as the water-cooled before they could be put into service. The possibility, however, of having 10 gallons of one's drinking water boiled away in 10 minutes was a serious one. As regarded Egyptian mechanics, they had been taken on to some extent, and many of them were extraordinarily good, especially mechanics in repair shops and on M.T. Also many Maltese carpenters had been taken on, and they were also very good. He was afraid he could not express any opinion with regard to commercial letters at present.

The LECTURER said he had stated in the Lecture that he did not think it necessary to have metal machines if they were going to operate in a tropical climate only, but he felt if one were going to fly from England through Bagdad to Bombay and back with the same machine one would have trouble with wood. Wood machines were all right if one stuck to a route between Cairo and Bombay.

# SOCKETS FOR WIRE CABLES.

BY WALTER A. SCOBLE.

An earlier article* dealt with so many matters in connection with wire cables that it was possible to pay but scant attention to sockets. A socket is a neat, light and convenient form of end connection for a cable. It is widely employed in general practice, but its use in connection with aircraft appears to have been confined to airships. The photograph shows different types and sizes of sockets viewed in several directions.



That on the extreme left is made of low tensile steel and is an example of the usual commercial type. Three of each of these types of airship sockets are included to give three views so that the form can be clearly seen. The sample on the extreme right is unnecessarily heavy. Those seen in the centre of the photograph are best for aircraft. They are very light and taper in one direction only so that they have small wind resistance. The top forms a pin joint.

To form this type of end connection the cable is passed through the circular end of the socket. The opening is just large enough to take the seized cable. The wires are allowed to open out and separate in the tapered socket, and a hard solder is poured in which adheres to the wires, but not to the socket, and so forms a wedge. When the cable is put under tension the wedge of solder draws slightly down the socket and closes on the wires.

* "Wire Cables." AERONAUTICAL JOURNAL, October, 1920.

The socket should not be too large; it must be fairly well filled by the cable, or the cable may draw out by shearing the solder. On the other hand, if the socket is too small, particularly if the cable is composed of a large number of wires, there is not sufficient room to allow the metal to run down and form a good wedge. These points are mentioned here, but are not likely to give trouble in practice. A socket which just takes a cable is generally satisfactory, but if a 7 × 37 wire cable is used, it can be made to enter a standard socket which is too small to take the large number of wires.

The table is included to indicate the dimensions of a range of sockets which have given satisfactory service on airships. They were made of steel to Specification S.2 by Cradock and Rylands.

| Cable strength. | Length, end of socket to pin centre. ins. | Width. ins. | Maximum breadth. ins. | Wall thickness. ins. | Pin diameter. ins. | Weight. (including pin and pulley). lb. |
|---|---|---|---|---|---|---|
| 25 cwt. ... | $1\frac{9}{16}$ | $\frac{5}{16}$ | $\frac{9}{16}$ | $\frac{1}{16}$ | $\frac{3}{16}$ | .047 |
| 2 tons ... | $1\frac{15}{16}$ | $\frac{18}{32}$ | $\frac{11}{16}$ | $\frac{8}{32}$ | $\frac{1}{4}$ | .098 |
| 3 ,, ... | $2\frac{5}{8}$ | $\frac{1}{2}$ | $\frac{15}{16}$ | $\frac{9}{32}$ | $\frac{5}{16}$ | — |
| 4 ,, ... | $3\frac{1}{4}$ | $\frac{9}{16}$ | $1\frac{3}{16}$ | $\frac{3}{32}$ | $\frac{3}{8}$ | .247 |
| 8 ,, ... | $3\frac{1}{4}$ | $\frac{3}{4}$ | $1\frac{7}{16}$ | $\frac{8}{16}$ | $\frac{7}{16}$ | .483 |

The coated wire used for aircraft cable is very suitable for socketing, and a satisfactory job can be made by a semi-skilled workman if the cable is composed of several strands. Single strand does not always present sufficient surface to be held by the metal up to the breaking point.

The following instructions were drawn up for the procedure during socketing.

The end of the cable will be bound. Note the place on the cable which will come at the end of the socket and put on a binding in this position. This serving may be of binding wire, but for smaller ropes tarred twine is to be preferred. It holds the cable together when the end serving is removed to spread the wires. The length of this serving should be from $\frac{1}{4}$in. for 15cwt. cable to $\frac{1}{2}$in. for 7-ton rope.

Thread the cable into the socket. Take off the end binding and spread the wires.

Bind the cable with asbestos cord for a short distance from the end of the socket to protect it from heat.

Heat the socket gently at the eye end until it can just be touched by the finger and thumb at the other end. Be extremely careful not to overheat the cable where it leaves the socket.

Put powdered resin into the hot socket and pour in melted solder (Tinman's).

Clear out any excess solder to allow sufficient clearance below the pin.

These instructions were prepared because it was found that in certain cases the wire was overheated at the small end of the socket and that failure consequently occurred there. Even when failure occurred as a result of overheating, the strength was not greatly below that of the original wire as the table shows.

| Nominal strength of cable, cwt. ... ... | 15 | 20 | 25 | 35 |
|---|---|---|---|---|
| Load when fractured at socket, cwt. ... ... | 15.2 to 19.4 | 19.0 to 22.1 | 22.1 to 26.3 | 29.5 to 37. |
| Average, ditto, ditto ... | 17.4 (11) | 20.4 (6) | 24.1 (20) | 32.9 |

It should be noticed that these results refer to fractures at the socket which occurred during routine testing, when the socketing was done under service conditions and no special precautions were taken. Even then the results were not very bad, because clear breaks, which allowed the full strength of the cable to be developed, were the general rule and the socket breaks were exceptional.

After the instructions were issued it was found that failures were extremely rare and the damage could be detected by the discoloration of the wire. In all other cases of the many hundred samples that were tested, the wire failed well clear of the sockets.

This type of end fitting was found to be the only practical way of testing samples of K.B. wire. K.B. wires are of specially high tensile steel 150-160 tons/in., and very thorough research into the failure of these wires under shock and vibration was conducted. For these tests the taper socket was the end connection and gave completely satisfactory results, as it developed the full strength even of this specially high tensile wire under the severe treatment.

Several hundred samples of kite balloon cables (7.1 tons) were socketed at each end for testing. This method proved entirely satisfactory, but for these larger ropes Babbitt metal No. 1 replaced solder, and the sockets were not heated. Heating the socket allows the metal to run in better, but if the wire of the cable is annealed where it leaves the socket, its strength is reduced. Dewrances' alloy No. 232 was even better for socketing, but Babbitt No. 1 was preferred because it is a standard alloy.

In connection with the point raised that the socket must be large enough to allow the metal to run well down, a case occurred when the cables broke in the sockets, in one case at a tension of 6.36 tons, and the best result which could be obtained was a strength of 7.6 tons. Circular sockets were available and were bored out to $\frac{1}{16}$in. and $\frac{1}{8}$in. larger diameter. In each case the eye of the socket was broken at from 8.7 to 9.1 tons tension.

It is hoped that this brief account will suffice to present the advantages of this type of end connection. When no special precautions were taken, the results were good, but if a few simple rules are observed, the full strength of a cable is always developed.

In conclusion, the essential features are repeated :—

Use hard solder for small sockets and a harder metal, such as Babbitt No. 1, for large cables.

The socket must be large enough to allow the metal to run through.

The socket should not be heated, but if it is small for the cable and heat is applied, protect the cable where it leaves the socket.

# STANDARDISED STABILITY TERMS.*

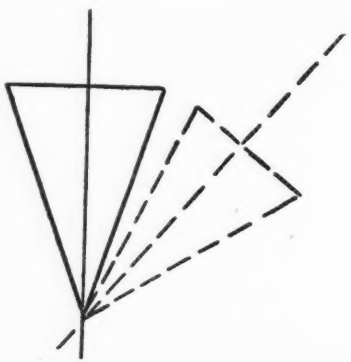
1. *Introductory.*—In the course of inquiries made recently by the Accidents Investigation Sub-Committee they were impressed by the fact that the various terms normally used to describe the characteristics of an aeroplane in regard to its stability or instability are incomplete and defective from a pilot's point of view. Not only did there appear to be differences in the meanings attached to the various stability terms by pilots and others, but in several cases the meanings were not in accordance with the definitions used in physical science generally.

It appeared that a scheme of definitions could be drawn up which would be acceptable both to those interested practically and theoretically in the subject. Definitions are needed for discussions on stability and particularly in making more definite the information given by pilots when describing the behaviour of aeroplanes. It is felt that the definitions, if accepted on all hands, would lead to such observations during the life of an aeroplane as materially to assist the investigations of accidents. In arriving at agreement on the definitions which follow, the Sub-Committee have been fortunate in having the assistance of representatives of each of the branches of the subject.

2. *Stability and Instability.*—The term "stability" is not confined in its uses to aeronautics. There are standard works by Routh, Kelvin and others relating to the motion of both solids and fluids. It seems to be very desirable that, so far as possible, aeronautical applications should conform with older usage.

If one considers a body—such as a cone at rest on its apex—with the point of support exactly below the centre of gravity, the general definition of its condition is that of *unstable equilibrium.* There is no tendency for the body to fall one way or another until a disturbance occurs; a disturbance having occurred, the body falls over and does not tend to recover its initial position, but takes up a position of stable or neutral equilibrium when laid on the ground.

Had the point of support been above the centre of gravity as in a conical pendulum, the effect of a disturbance would have been to produce an oscillation about the mean position. At rest, the pendulum is in *stable equilibrium.*



If one considers the body to be released when in the dotted position it is unprofitable to speak of its stability, since it is not in equilibrium and will fall

* Aeronautical Research Committee Reports and Memoranda, No. 745. June, 1921.

without any accidental disturbance. Mathematically, one only considers the stability of a position of equilibrium or the permanence of a state of steady motion.

*Balance.*—The expression which is partly in use, and is recommended for the purposes of defining the condition of an aeroplane in a state of steady motion, is that it is in "balance."*

In longitudinal motion, if there be no force on the control column, so that the attitude of the aeroplane is not changed by the removal of the pilot's hand, then the aeroplane is commonly said to be in longitudinal balance. For example, whether the adjustable tail plane be locked mechanically or the elevator be locked by being firmly held, it is in either case legitimate to speak of the aeroplane as in balance.

A less common use of the word carries the above idea forward from longitudinal to lateral motion, and it is recommended that "balance" should correspond with the idea of steady motion generally, the qualifying adjectives "longitudinal" and "lateral" being used for the purpose of restriction.

It would appear to be a logical extension of existing usage if the word "balance" be applied also to any steady motion of an aeroplane for which the controls are held or locked.

*Steady Motion.*—When the motion of an aeroplane is steady, its attitude, its airspeed, its rate of turn and its angle of bank do not change from instant to instant.

3. In applying these ideas, it is desirable to avoid the expression "stable aeroplane."† For example:—

(*a*) The straight line motion of an aeroplane may be stable or unstable.
(*b*) The circling flight of an aeroplane may be stable or unstable.
(*c*) The spinning nose dive of an aeroplane may be stable or unstable.
(*d*) There is no point in speaking of the stability of a loop or roll. During these manœuvres the aeroplane is changing its attitude and speed, and is therefore not in a steady motion.

4. Ideas are complicated by the consideration of similar manœuvres with certain controls locked or free. If an aeroplane be flown with controls used so that its path is steady and the rudder bar be then abandoned, the motion will almost certainly change. This should not be described as instability, since it follows from the fact that the rudder changes its position when the rudder bar is released. It is to be regarded as an effect of movement of control and is analogous to the change of longitudinal motion which accompanies use of the elevator.

With this introduction one would say:—

(*e*) A given type of steady motion is *stable* if the aeroplane will continue in that state of motion without movement of the controls by the pilot.

(*f*) A given type of steady motion is *unstable* if the aeroplane will not continue in that state of motion without movement of the controls by the pilot.

5. Explanations of terms relating to stability are given below.

---

* "Trim" has in the past sometimes been used as synonymous with "balance." It is recommended that the word "trim" be reserved for a "rigging" operation.

† The definition of a stable aeroplane as one which, whatever be done to it, the aeroplane comes back to straight flight on releasing or centralising the controls, is to be discouraged, since it is far less useful than the new proposal when it is desired to refer to the various qualities or behaviour of an aeroplane for variations of flight conditions.

*Stability and Instability of a Weathercock.*—If the conventional type of wind vane points into the wind, it is said to possess weathercock stability. This effect is obtained by putting a large fin area behind the supporting spindle. If the vane does not keep into the wind when set there, but blows round to some position away from the wind, the condition is one of weathercock instability.

*Weathercock Stability and Instability of the straight line motion of an Aeroplane.*—The aeroplane is presumed to be controlled by the pilot so as to be flying straight with the wings horizontal. At some instant of time the *rudder bar is locked.* A disturbance occurs and the ailerons are used to keep an even keel. If the aeroplane becomes yawed, *i.e.*, is sideslipping either to right or left and to increase the amount (indicated by the cross level of the aeroplane), the straight line motion exhibits weathercock instability. If, on the other hand, the aeroplane continues to fly straight, the motion has weathercock stability.

In still air the test for weathercock stability would be given by a kick to the rudder bar with immediate return to its previous position. Before the kick the aeroplane is flying straight with wings horizontal, and during the further motion the ailerons are used to maintain an even keel. Weathercock stability exists if there is return to a straight path, though in a new direction.*

The weathercock stability and instability of the circling flight of an aeroplane can be determined by analogous considerations.

*Rolling Stability† of the straight line motion of an Aeroplane.*—The aeroplane is presumed to be controlled by the pilot so as to be flying straight with the wings horizontal. At some instant of time the *ailerons are locked,* but the rudder is still used to keep a straight path. If, whenever one wing goes down due to a "bump," and tends to return to the horizontal, the motion is stable. If, on the other hand, the wing tends to go down further, the motion shows "rolling instability." The motion is not pure rolling,‡ but is accompanied by sideslipping.

In still air, the test for rolling instability would be given by a jerk on the ailerons sufficient to depress one wing. If, after subsequent return of the control column, the aeroplane tends to resume an even keel, there is "rolling stability."

It is useful to extend the definitions of rolling stability to cover the case in which ailerons are abandoned. Qualifying notes are then needed in applying the definitions, and these may be "rolling stability ailerons locked" and "rolling stability ailerons free."

*Rolling Stability of Circling Flight.*—If an aeroplane can be kept on a given turn in bumpy weather by means of rudder and elevator only its circling flight has rolling stability, or, alternatively, if the aeroplane on such a turn tends to correct a change in angle of bank due to a gust without the use of ailerons, its circling flight has "rolling stability."

*Lateral Stability of the Straight Line Motion of an Aeroplane.*—The aeroplane is presumed to be in straight flight with the pilot in control. At a chosen instant *both ailerons and rudder are locked.* The elevator is used only to maintain steady speed and attitude. If the aeroplane continues in straight flight the motion has complete *lateral* stability. The motion of an aeroplane may have both "weathercock" and "rolling" stability and yet not have complete lateral stability. Departure from the straight path may occur (*a*) by weathercock instability, (*b*) by an increasing oscillation in roll and yaw, or (*c*) by the starting of a turn which becomes overbanked. The second of these (*b*) is described as an

* When an even keel is maintained by means of the aileron and a constant angle of incidence by the elevator, the effect is to preclude any rotation except about the vertical axis.

† This has sometimes been described as "lateral stability," a term the true meaning of which is given below. It is recommended that such use be discontinued, as the term has another and more important use dealt with elsewhere.

‡ The motion has no connection with the "aerobatic manœuvre" called a "roll."

unstable lateral oscillation; the last (c) presents greater difficulties, and has hitherto been called "spiral instability." The name now suggested is "yaw-roll instability." An aeroplane having the defect (c) tends to start an increasing turn with increasing bank, thereby taking up a converging spiral path.

*Lateral Stability of Circling Flight.*—If before locking the ailerons and rudder the flight is one of steady turn, corresponding definitions will hold. Modifications may also be desired for ailerons free, but rudder locked.

It is strongly recommended that the term "lateral stability" be restricted to those cases when the motion is completely stable. This conforms with the use in physical science. Any motion which involves rolling, yawing and side-slipping in any relation whatever is included in lateral motions. It is because the term "lateral stability" is generic and inclusive that it must not be used for a particular case, such as "rolling" stability.

6. Perhaps an illustration of the use of ideas in relation to spinning may help to emphasise the need for the definitions given to balance and stability.

*Spinning.*—An aeroplane is flying steadily and horizontally at a given instant at an angle of incidence below stalling. The design of the aeroplane is assumed to be such that the pilot has been able to adjust the controls so that, when locked, the aeroplane continues to fly itself straight at, say, 90 m.p.h.

(*a*) We then conclude that the straight line motion of the aeroplane at 90 m.p.h. is longitudinally and laterally stable with all controls locked.

At a given instant the stick is pulled back and the engine is throttled down.

(*b*) The aeroplane is now out of balance—longitudinally by change of engine power and movement of elevator, laterally by the change of slipstream over the fin and rudder. Considerations of longitudinal stability are excluded by this lack of balance.

It will be assumed that the rudder is used to maintain lateral balance* until the aeroplane is stalled while being on an even keel, and it is then possible to consider the stability of the lateral motion when the longitudinal changes have overstalled the aeroplane.

(*c*) The lateral motion of the aeroplane becomes unstable and one wing drops, the aeroplane puts its nose down and rotates. After a little time the spinning nose dive is fully developed.

(*d*) Whilst the stick is held back the spinning continues and the motion is stable (minor effects of rudder are ignored).

The stick is put forward and the rudder centralised.

(*e*) The spinning nose dive becomes unstable laterally and the spin tops, leaving the aeroplane in a dive, *i.e.*, out of balance longitudinally.

(*f*) The stick, rudder and engine throttle are brought back to the positions at the beginning of the manœuvre and the aeroplane resumes its steady horizontal flight at 90 m.p.h., this being by hypothesis the stable condition for the pre-supposed position of the controls.

(Signed) MERVYN O'GORMAN,
*Chairman, Accidents Sub-Committee.*

* This is probably a departure from usual practice, but is a possible motion.

# ORGANISATION OF A COLONIAL AIRSHIP SERVICE.

*Lecture delivered before the Royal Aeronautical Society, Scottish Branch, on October 17th, 1921.*

BY LIEUT.-COL. V. C. RICHMOND, O.B.E., B.SC., A.R.C.S., ASSOCIATE FELLOW.

## (1) Introduction.

I feel it a great honour to have been asked by this Society to speak to you this evening on this subject. The question of the utilisation of airships for commercial purposes has attracted an immense amount of public attention during the past year. Unfortunately, owing to the high costs of running airships experimentally, the Air Ministry have been faced during this period with the necessity of having to abandon airships for military purposes, and also of having to cease their experiments on the use of these ships for commercial purposes. Fortunately it is inherent in the British temperament to give its greatest sympathy to a man when he is down, and for this reason, concurrently with the complete cessation of all airship activities, such stupendous ideas as the use of airships for linking up the Colonies have been put forward. The scheme for using aircraft on such an unprecedented scale for commercial purposes is so gigantic as to call for very grave and careful consideration.

Ever since the armistice airship pioneers and experts have been giving the problem their attention, and it has been entered into in far greater detail than ever the public imagine probably. Since I received your Secretary's invitation to lecture to you we have been faced with the tragic disaster to R.38, with the loss of all those courageous and brilliant men who, as I say, have been giving this problem their most earnest consideration for the past three years.

A good deal has been written in the Press on this subject, but I feel it all the greater honour that the task should have been allotted to me of presenting to you this summary of the project which these men had so closely at heart.

Let me say at the outset that my acknowledgments and best thanks are due to Air Commodore Brooke-Popham, Director of Research, for permission to give this lecture, and also to Major G. H. Scott and other officers of the C.G.C.A. and Directorate Research Departments of the Air Ministry for their kind assistance in the preparation of some of the matter. I need hardly add that any views I may express must not necessarily be taken as the official views of the Air Ministry.

I shall have occasion later to refer briefly to the comparative value of aeroplanes and airships for commercial communication with the Colonies, but you are probably familiar with the contention that the airship is peculiarly suited for long distance voyages over the sea, or for routes which necessitate at present mixed land and sea journeys with all their attendant inconveniences. You will readily appreciate that in this respect the British Empire is unique, possessing a large number of such routes with a well established flow of passengers and goods only waiting to be increased by more rapid means of transport. I would draw your attention to the fact that the committee, recently set up by the Dominion Premiers to advise them on aerial communications, did not question in any way the ability of airships to carry out the services which experts claim for them, and therefore the soundest and most profitable ground for development of commercial airship transport is the British Empire. I will go further and say that it is absolutely essential, with such a scattered empire as ours, that we should be foremost in

this development, as rapidity of communication is the most vital of all military and economic influences.

It will not be out of place, perhaps, if at this point I digress for a moment to give a brief account of the airship activities of other countries at the present time, as far as we know them.

**(2) Airship Activities of other Countries.**

(*a*) **America.**

The United States of America are taking a very vital interest indeed in the question of airship construction, both for commercial and military purposes. The largest airship shed in the world has been erected by them at Lakehurst, New Jersey, the shed being capable of accommodating one airship of ten million cubic feet capacity, or two airships of five million cubic feet capacity each. Sheds are being erected at Cape May and Langley Field slightly larger than the largest existing sheds in England, capable of housing airships of up to four million cubic feet capacity. The erection of a base on the Pacific coast is also contemplated. The Americans are considering the question of design and construction very thoroughly indeed, and are at present engaged on the construction of a rigid airship similar to the German L.49 type. Most of the prominent German airship constructors have visited America and there is every evidence that in some cases their services have been bespoken. It is also well known that the Americans are trying to acquire from the Zeppelin Company an airship whose performance should far exceed that of any of the ships which have so far been produced. A company, termed the "General Air Service Company," is being formed for the purpose of operating commercial airships on trans-continental and trans-oceanic routes. It has very good backing from several of the large commercial corporations, and it is likely to begin extensive operations in the near future.

Perhaps one of the most striking facts with regard to the American interest in airships is the large amount of money which has been spent on a plant erected at Fort Worth in Texas for the production of helium. Helium is an absolutely non-inflammable and inert gas with a 96 per cent. lift of pure hydrogen. You will see that it would be ideal, therefore, for use in airships, and the Americans are singularly fortunate in possessing large supplies of natural gas which contain a comparatively large percentage of helium. Even so, the work of extracting the helium is an expensive one. The plant cost approximately $3\frac{1}{4}$ million dollars and produces 40,000 cubic feet of helium per day. I understand that the United States have placed an embargo on the export of helium, which shows how important they regard the matter.

(*b*) **France.**

France possesses three German airships, handed over under the terms of the Peace Treaty—including L.72, which was one of the two largest airships built prior to R.38, and also the "Nordstern," the latest German commercial airship built since the Armistice. A large shed has just been completed near Toulon, and a second shed is under construction. At Maubeuge there is a shed constructed by the Germans during the war, and seven of the German airship sheds allocated to France under the terms of the Peace Treaty are being dismantled with a view to their re-erection in France and her colonies.

It is understood that the "Nordstern" is to be used on a commercial service between Marseilles and Algiers. The Algerian Assembly have approved the inscription in the 1922 budget of a credit of one million francs for the purpose of subsidising certain aerial services between Paris, Marseilles and Algiers, part of which is to be carried out with the "Nordstern." Such a service would complete the first link in a route to South America in which, it is understood, the French have considerable interest.

(*c*) **Germany.**

The Germans are precluded at present from building aircraft until three months after the satisfactory completion of all their obligations under the aerial clauses of the Treaty of Versailles. It is probable that they will be free in this respect by about next spring. The Zeppelin Company have been keeping their works going on motor cars and various other commercial articles with the object of being able to re-commence airship building at the earliest possible moment.

One of the long distance routes which they favour most is that from Spain to South America, and you will probably all have read in the Press that the arrangements for this route are pretty well advanced.

**(3) Historical Parallel.**

It is inevitable that many nations of the world will make every effort to derive the maximum benefit from this wonderful new instrument of transport as soon as may be. I can think of no parallel in history where any scientific development—which has reached the stage of advancement which airships have reached—has ever stood still. It has been said recently that "the airship is just as certain of being guided by energy and patience to achieve the end in view as Stevenson's 'Rocket' was of covering England with railway lines." Unfortunately, it is just as certain that it is experiencing, and will experience for some time to come, the same amount of prejudice as the "Rocket," the first steamship, the first motor car, and in fact the ordinary push bicycle had to contend with in their early days.

In reading the history of the development of shipping from early days I have been struck by the number of very close parallels it provides to the state of affairs through which the airships have passed and are passing now. I may perhaps be excused for pointing out some of these to you on the plea that pushing the analogy still further we may gain wise guidance for the future. Little more than a century ago the shipping of the world was engaged almost solely in carrying luxuries for the wealthy and in some cases transporting the more adventurous of them on voyages of business and pleasure. I suppose this represents with a fair degree of truth the kind of traffic with which the airship will endeavour to commence earning money. These islands by their geographical position were designed by nature to be the home of a great shipping community, just as I have said that the British Empire has the most advantageous routes in the world for the utilisation of airship transport. One sees that the old wooden sailing ships reached their prime in 1870 and that people could not imagine anything faster or finer than those racing clippers. Their names were as familiar as those of any football team are to-day, and their races home were followed with the keenest interest. But iron ships came, which it was proved could be built stronger for the same weight. The prejudice against them was colossal. Indeed the Chief Constructor of one of the Royal Dockyards said to Mr. Scott Russel, years after the success of iron for shipbuilding had been fully demonstrated: "Don't talk to me about ships of iron, it's contrary to nature." It is quite easy to make a mental flight over a few decades and hear the wiseacres saying: "Fifty tons of metal floating in the air—God never intended people to travel about like that—it's contrary to nature." The invention of the rolling mill by Henry Cort revolutionised the building of iron ships. Useful plates, channels and angles could be produced and unsatisfactory cast iron boilers could be given up. One's mind instinctively flies to the history of rigid airship building. First of all aluminium was used by Zeppelin—an unworkable metal with most unsatisfactory mechanical properties for the purpose. His rivals, the Schutte-Lanz Co., were quick to see the advantages of wood, which successfully held the field until Zeppelin countered this with the introduction of the famous duralumin alloy, which could be rolled and pressed into channels, etc. The introduction of steam into shipping was the signal for more mountains of prejudice. There were scientists who attempted to prove that

it would be an utter impossibility to steam across the Atlantic, the ships could not possibly carry enough coal, etc. "Foul steam kettles," said others, "they will all burst their boilers and you will be drowned." Can you not hear the man of to-day saying, "By the time the airship has got its fuel and ballast on board there is not sufficient lift left to make it worth running commercially; besides, hydrogen is so inflammable, the ships are bound to blow up." In 1825 a subscription of £8,000 was raised in India for a prize for the first steamship voyage from England. Later a prize of £500 was offered for the fastest steam passage to Australia. Special ships were built which eventually won these prizes, but which themselves were of very little use for commerce, although of course improved shipbuilding was stimulated. How like the great aeronautical competitions of to-day! In 1838 comparatively large subsidies were offered by the Admiralty (which was then responsible for the foreign mail service) for the carriage of the North American mails by steamship. This was not until their prejudice had been swept away by public opinion, which saw clearly that the steamship ensured both greater speed and greater regularity. The tender which was accepted led to the formation of the Cunard Co., which was extremely successful. The Americans, who were jealous of this success, offered a larger subsidy, which in turn had to be countered by a still larger subsidy to the Cunard Co. The parallel to the events of our time is perhaps too obvious for me to draw it here. Similarly, with regard to size. Who amongst the early steamship builders could have imagined a ship the size of the "Aquitania"? When only doubling the size of the early ships was mooted people said "it was madness, they would be too fragile, they could never stand a rough sea." Yet the "Aquitania" is at least six times as long as the early steamships. Similarly, with regard to airships. There seems no inherent reason why they should not be built in the future of very greatly increased capacity—rugged steel ships with metal plating for a cover. People did not refrain from building large steamships because of the cost of building larger docks, nor can I imagine them refraining from building large airships because of the shed costs. In any case the mooring mast, which is a comparatively cheap affair, will perform the equivalent functions of a wet dock, and the shed those of the dry dock or building slips.

Who calls the "Aquitania" a "foul steam kettle" now? Yet I have read the remarks of the chairman of the Imperial Shipping Committee on airships (I shall have occasion to refer to them again later), and it seems that speed, that great god of commerce, has marked down even the "Aquitania." Our fathers may not live to see the funeral, but the signs are unmistakable. Who is to foot the coal bill when the airships carry the mails and the millionaires?

### (4) The Comparative Value of Airships and Aeroplanes for an Imperial Air Service.

On the second of their terms of reference, viz., "On Services by means of Aeroplanes," the Imperial Air Communications Committee observe what appears to be a profound reticence. My own view on this matter is that the functions of the airship and the aeroplane respectively are truly complementary and do not overlap. For distances which are small compared with a normal long distance airship flight of, say, 2,000 miles, the aeroplane does, of course, possess definite advantages especially over land in its superior speed. There is no doubt that if sufficient bases were laid down with sufficient relays of aeroplanes a fairly regular service could be established by this means to the Colonies, but what the capital cost and annual expenditure of such a service would be I should not like to attempt to predict. I shall have occasion later to refer to the present volume of traffic between this country and the Colonies, both in passengers and mails. Even presuming that such a large proportion as half of this could be sent by air, I venture to think that, at any rate for the present, this volume of traffic would

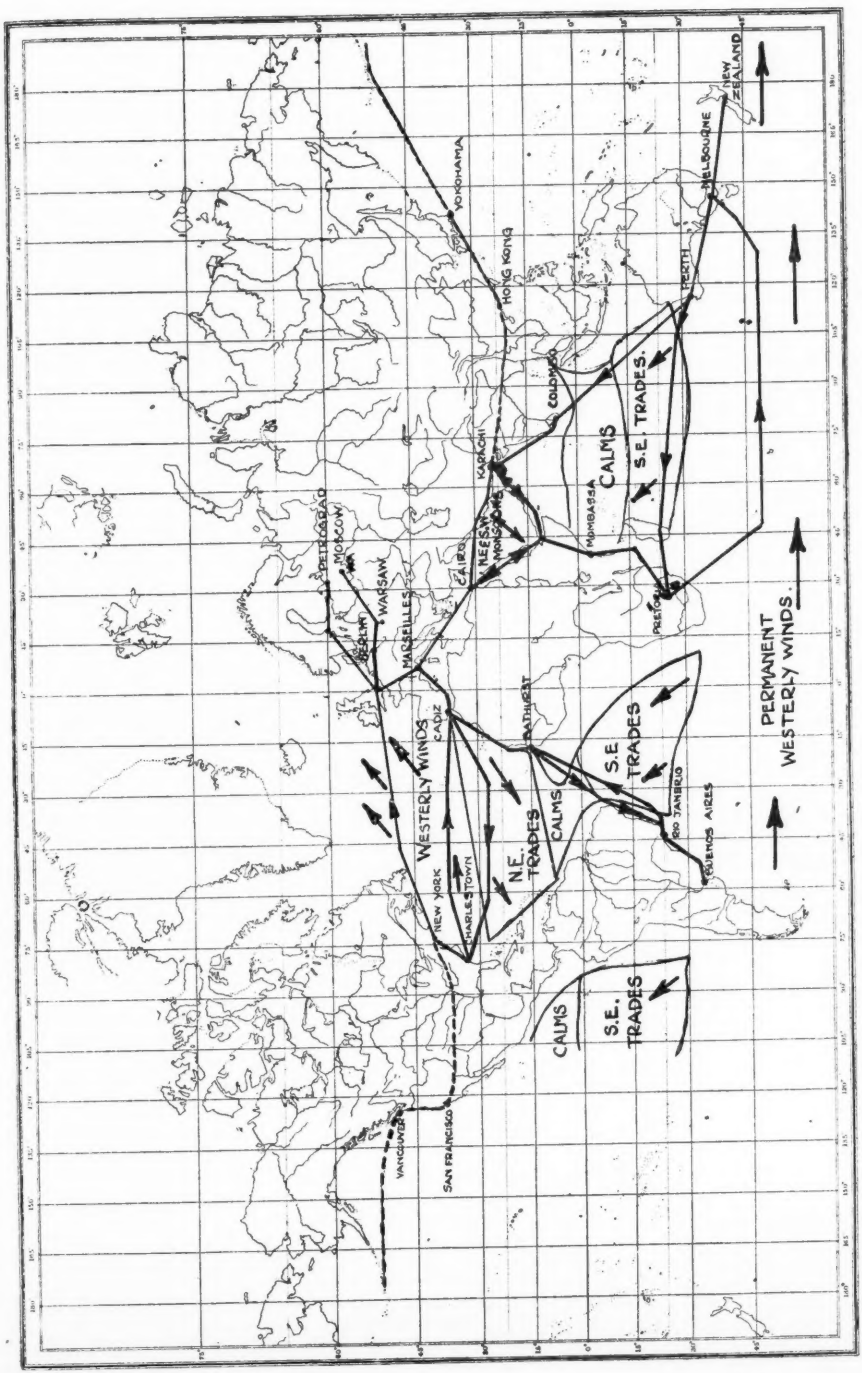
not be sufficient to justify the large capital costs of the many aeroplane landing grounds, etc., which would be required along the route. Also, it will be obvious to you that, although the actual air speed of the aeroplane would be considerably higher than that of the airship, the extra number of stops which would be required on a run of, say, 2,000 miles, would reduce the effective speed of the aeroplane very considerably.

The meteorological organisation of a service of this kind will have to be very good, and full advantage will have to be taken of prevalent winds. You will understand that the shorter the distance between the stopping places the less the opportunity of avoiding dangerous winds or meteorological conditions or of taking full advantage of the favourable ones. In this respect the airship on its long-distance non-stop run would have very definite advantages over the aeroplane. Fog and low-lying clouds are a distinct danger to the aeroplane, and as the frequent stopping places bind it to a pretty definite route, serious delays in the regularity of the service might be caused by such clouds or fogs, even although these might only occupy a limited portion of the route.

Generally speaking, the air speed of the aeroplane is about twice that of the airship and for short routes where a steady head wind may be encountered of 30 or 40 m.p.h. the speed of the aeroplane over the ground is more than twice that of the airship, while its regularity of flight is considerably greater. For this reason the aeroplane undoubtedly holds the field. Over short routes very great speed is essential. The route must be chosen with care, however, because in some cases even the high speed aeroplane will not possess the commercial advantages which might appear at first sight. Take for example the internal communications of Great Britain. If a business man in London wishes to go to Glasgow, Cardiff, Newcastle, or any of the other great business centres he can leave his office to-day at the usual time, take a comfortable dinner, proceed in a luxurious sleeping coach on the railway, have a comfortable breakfast at the other end and reach his business associate's office at the beginning of the day without undue mental or physical fatigue. Even if the aeroplane could fly with safety at night, which it cannot at present, the gain to the business man in flying from London to any one or other of the great industrial centres in two or three hours is almost negligible. The same thing applies to mail. If the business man can despatch his letter at the end of one day and his associate receive it the next morning, all ordinary requirements are satisfied. Any more urgent requirement is likely to be met much more effectively by a good telephone system than by rapid aeroplane transport.

The question of mental and physical comfort in travel is a vital one. Presuming that the present type of aeroplane were used on these long distance routes, I very much doubt if more than eight to ten hours flying per day would be accomplished. In order to effect a reasonably rapid journey this ten hours per day would have to be kept up for every day throughout the flight. The amount of transhipment and the anxiety of the continual landings would, in my opinion, make ten hours flying by aeroplane per day every day quite unsupportable by the average business man.

I should like to repeat, however, that I consider the functions of these two classes of aircraft are distinctly complementary. When communication between one large centre in each colony has been established by airship, the aeroplane will assume a very definite and important roll in distributing passengers and mail, and freight from that centre to the various parts of the colony with the minimum loss of time. It would be very galling for instance if having made the journey by airship from England to India in, say, five days, one was then obliged to spend two days in a train to reach some destination, say 800 miles from the landing terminal.


PERMANENT
WESTERLY WINDS.
WESTERLY WINDS
N.E. TRADES
CALMS
S.E. TRADES
CALMS
S.E. TRADES
CALMS
S.E. TRADES
CALMS
S.E. TRADES
PETROGRAD
MOSCOW
BERLIN
WARSAW
MARSEILLES
CADIZ
KEESAW
MONSOONE
KARACHI
COLOMBO
MOMBASA
PRETORIA
PERTH
MELBOURNE
NEW ZEALAND
YOKOHAMA
HONG KONG
NEW YORK
CHARLESTOWN
BATHURST
RIO JANEIRO
BUENOS AIRES
VANCOUVER
SAN FRANCISCO

**(5) General Organisation.**

You may have noticed that, although the Committee on the Imperial Air Communications have devoted the bulk of their report to estimates of the cost of running a State airship service, they make the following significant remarks in their preface:—

"The Committee take the opportunity of observing that in their view the best hope of the successful development of Imperial Air Communications lies in private enterprise conducting the service for profit, like the Mercantile Marine, on business lines."

There is no doubt that airship communication with the colonies can only make healthy development on such lines. It is obvious that the organisation must pass through an experimental development period of probably three or four years before it can reach the stable conditions of regular freight and passenger traffic, such as I have laid down later in the section dealing with financial organisation. It would, however, be quite unsound to legislate for this period of experiment only, owing to the fact that the bases, mooring masts, ships, etc., which would be required must be so laid down and designed as to be suitable for continuous commercial traffic at the end of the experimental period, because of the high costs involved. For this reason I am inclined to regard the existing airships as being of not very great utility and, in fact, of much less value than has commonly been placed on them. I feel, however, that a certain amount of useful information would be obtained and the public would learn to gain more confidence in the utility of the airship if the existing ships were run on some comparatively short route which did not involve any great capital expenditure. A route such as Cardington to Marseilles would be ideal in this respect as there would be terminal facilities at each end and the only capital outlay would be for the repair and re-commissioning of two of the existing ships, a comparatively small matter. Incidentally it would link up with the proposed French service to Algiers. From the experience which the Germans gained in running the "Bodensee" between Lake Constance and Berlin there seems no reason to doubt that sufficient passengers and freight could be found for the "Marseilles-Bedford" route and that with a subsidy of the order of 25 per cent. of the gross takings, such as is at present paid to the Cross-Channel aeroplanes, the service could be run without loss. I feel that any attempt to use the existing airships for longer routes than this would definitely be a mistake. Some information might be obtained, but it must be remembered that these ships were all built for war purposes and many improvements have been effected since they were designed four years ago. It would be folly, therefore, to make the case for the airship stand or fall on the performance of these craft in a service for which they were never designed or intended.

It may be gathered from the Imperial Air Communications Committee's report that, generally speaking, the capital expenditure which will be required to finally establish a weekly service both ways to each of the Colonies, India, South Africa and Australia, would be in the region of four million pounds. Such a service would take about four to five years to establish. It is obvious that any commercial undertaking during that five years would require very considerable Government assistance to enable them to carry out their project. From a study of the various proposals which have been made to the Air Ministry, it will be seen that the general opinion is that the subsidy required would be in the region of £300,000 per annum and that, with the guarantee which this subsidy would bring, the capital sum of four million pounds required could be raised. Seeing the scale of the project which is to be undertaken it does not seem unreasonable to suppose that this sum could be found between the Dominions and the Mother Country. You will probably have noticed from the Press that Mr. Hughes, the Prime Minister of Australia, is to place before his Parliament a scheme for airship development involving a grant by Australia of £250,000 to cover two

years' work. Unfortunately, the details of his proposals are not yet to hand, but if this money is actually granted by the Australian Parliament and sums commensurate with it are granted by the Parliaments of the other Dominions and this country, the assistance should be sufficient to enable the Imperial Airship scheme to go forward on healthy lines. As far as this country is concerned, a grant of £660,000 has been made to cover three years for a mere Cross-Channel aeroplane service. Also about 45 million pounds have been spent already on the airships, and therefore a subsidy of, say, £200,000 per annum by the Home Government, would not appear an unreasonable amount to ensure that the great benefits which would arise from an Imperial Airship Service should be secured as a return for this huge expenditure. It seems pretty clear also that any such sums set aside by the various Parliaments would be far better spent as a subsidy to a commercial undertaking than on a State service, because with the subsidy as guarantee of interest the commercial concern could secure the benefits of large capital.

Under such an arrangement it is suggested that the State's rights in the commercial airship company should be as follows:—

(1) First call on the available accommodation for the conduct of imperial business.

(2) Absolute control of the fleet in time of war.

(3) Facilities, if necessary, for training Government personnel on the airships in time of peace.

(4) Full use of the company's aerodromes and facilities for military aeroplanes on terms to be agreed.

(5) The Air Ministry to have a seat on the Board of Directors.

As I shall suggest later on in considering the question of revenue, the company should carry an amount of mail equal to approximately half the present mail traffic to the colonies specified, at a cost of 6d. per oz. to India and South Africa and 9d. per oz. to Australia. The definite co-operation of the Government would be necessary to this end.

It will be noticed that in their considerations the Imperial Air Communications Committee have dealt solely with the Colonies of India, South Africa and Australia. It is natural that an Imperial Airship Service should develop first in this direction. The first part of the route as far as Egypt is common to all three services, and also these Colonies would have most to gain from such a service. Therefore, in what follows I have confined my attention almost exclusively to these three colonies.

The reason why airship communication is not likely to develop with Canada until much later is that the whole of the journey would be over the sea, where, of course, no intermediate stopping places can be arranged and the distance between the terminals would be about 3,000 miles, whereas with the type of ship contemplated for the service to the East, a 2,000-mile journey is about the economic maximum. It must also be remembered that comparatively high speed luxurious steamship travel has been provided across the North Atlantic, and there is plenty of traffic in that class of passenger who can easily pay sufficiently high prices to make it worth while running such a costly steamship service. It is, therefore, unlikely that the service to Canada will develop until considerably larger and faster ships are built than we have any experience of at present.

One of the points to be carefully studied in the organisation of any airship service is the avoidance of dangerous weather conditions and the necessity of taking full advantage of favourable winds. There are practically no favourable winds for passage westwards across the North Atlantic, and probably head winds will be encountered all the way. The speed made good over the area in which head wind is experienced is the difference between the speed of the airship in still

air and the speed of the wind. I should like to give you the following simple example to show how important a small increase in the speed of the airship becomes under these conditions. A ship of 50 knots speed proceeding against a wind of 40 knots only makes good ten knots, and if the area of the head wind is 100 miles, the time taken would be ten hours, during which the ship would have flown 500 air miles, so that 400 air miles are wasted. Now imagine that the ship is so constructed as to be capable of an independent speed of 60 knots, *i.e.*, an increase of one-fifth of the speed previously considered. Her ground speed would then be 20 knots under the conditions stated above, and the time taken over the area of head wind would be five hours and the air miles flown would be 300, thus only 200 air miles are wasted as against 400 in the previous case. I am quoting Major Scott when I say that it is considered that an airship with a speed of 70 knots could carry out a regular service across the North Atlantic at any time of the year.

**(6) Technical Organisation.**

(*a*) **Ground Organisation.**

In the attached map you will see indicated roughly the proposed routes, together with a general indication of the various winds which would be experienced over these routes. It is natural that the position of bases and mooring masts are to a certain extent governed by geographical conditions. At the same time there are economic factors to be considered governing the best distance apart for these calling places, and these I will now briefly indicate.

Annual costs may be divided into two parts:—

(*a*) The cost of upkeep of bases and ships, plus the cost of insurance, staff, etc., not including gas and petrol. (This may be termed the terminal cost.)

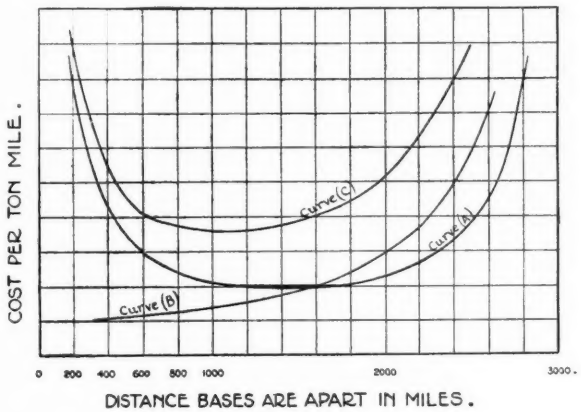
(*b*) Running cost of airships. This includes the cost of petrol and gas.

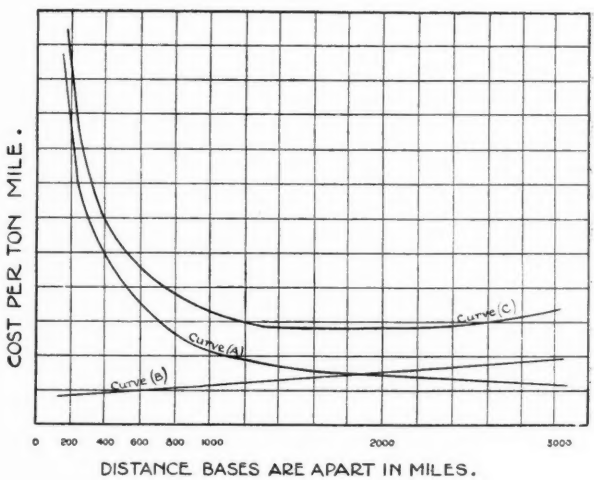
You will readily understand that whatever distance the bases are apart the costs under (*a*) will remain the same, so that the terminal cost per ton mile decreases as the distance apart of the bases is increased, but the weight of petrol carried increases with the distance to be flown, so that the available lift for cargo decreases with the distance. The terminal cost per ton mile should, therefore, be divided by the weight of freight carried to give a factor connecting terminal costs with the distance between successive terminals. I have indicated this in curve A on Chart I.

The running cost per mile remains the same, however far the bases are apart, but as before, the weight of freight decreases with the length of the journey, so that the running cost per ton mile increases with the distance apart of the bases. This is shown in curve B. If we combine these two curves we get curve C, the lowest point of which indicates the most economical distance apart for successive bases. The introduction of an intermediate mooring mast modifies the situation considerably as terminal costs for this are small; chart 2 shows this. These curves are only meant to be diagrammatic and hence only approximately represent an actual case. Bearing in mind these considerations, and those applying to geographical conditions and prevalent winds, the attached map shows the positions which are contemplated for bases and mooring masts. These are as follows:—

England—for the present Cardington (Bedford), where the mast which has been dismantled from Croydon would be re-erected with an additional mast. The existing airship shed would have to be lengthened and, in order to deal with the construction and repair work which will be required when the service which I am outlining has been established, two additional airship sheds will also be necessary.

Near Marseilles the French have a large airship station where it is hoped a mast will be erected which would serve as an intermediate stopping place on the first long run to Cairo. At Cairo a base would have to be constructed which will consist of a shed at present owned by the British Government, part of which is erected and part of which is still lying at the maker's works, a mooring mast, hydrogen plant and all the other etceteras required by a base. As far as Cairo the route would be common to the three colonial services contemplated. Taking




first the Indian route, it is considered that this could be successfully operated from the Cairo base with merely a mooring mast station at Karachi. For the South African route, a new base with mooring mast would be required near Durban, and an intermediate mooring mast, say at Mombasa. The route to Australia might be operated either via the African base or via India, but there seems little doubt that the former alternative is the better one to choose owing to the prevalent winds. In sailing eastward from Durban to Melbourne in

## TIME TABLE FOR AUSTRALIAN SERVICE VIA SOUTH AFRICA.

FIVE AIRSHIPS REQUIRED LETTERED A, B, C, D AND E RESPECTIVELY.

| Day. | | England. Arrival. | England. Depart. | South Africa. Arrival. | South Africa. Depart. | Australia. Arrival. | Australia. Depart. | |
|---|---|---|---|---|---|---|---|---|
| Mon. | 1st week. | | A | E | | | D | |
| Tues. | | | | | E | | | |
| Wed. | | | | D | | | | 7 days' flying. |
| Thur. | | C | | | D | E | | |
| Fri. | | | | | | | | |
| Sat. | | | | | | | | |
| Sun. | | | | | | | | |
| Mon. | 2nd week. | | B | A | | | E | 1 day's rest. |
| Tues. | | | | | A | | | |
| Wed. | | | | E | | | | 3 days' flying. |
| Thur. | | D | | | E | A | | |
| Fri. | | | | | | | | 3 days' rest. |
| Sat. | | | | | | | | |
| Sun. | | | | | | | | |
| Mon. | 3rd week. | | C | B | | | A | |
| Tues. | | | | | B | | | 3 days' flying. |
| Wed. | | | | A | | | | |
| Thur. | | E | | | A | B | | 1 day's rest. |
| Fri. | | | | | | | | |
| Sat. | | | | | | | | |
| Sun. | | | | | | | | |
| Mon. | 4th week. | | D | C | | | B | 7 days' flying. |
| Tues. | | | | | C | | | |
| Wed. | | | | B | | | | |
| Thur. | | A | | | B | C | | |
| Fri. | | | | | | | | |
| Sat. | | | | | | | | |
| Sun. | | | | | | | | |
| Mon. | 5th week. | | E | D | | | C | |
| Tues. | | | | | D | | | |
| Wed. | | | | C | | | | 10 days' rest. |
| Thur. | | B | | | C | D | | |
| Fri. | | | | | | | | |
| Sat. | | | | | | | | |
| Sun. | | | | | | | | |
| Mon. | 6th week. | | A | E | | | D | |
| Tues. | | | | | E | | | |
| Wed. | | | | D | | | | |
| Thur | | | | | | | | 7 days' flying. |
| Fri. | | | | | | | | |
| Sat. | | C | | | D | E | | |
| Sun. | | | | | | | | |

## TIME TABLE: ENGLAND—S. AFRICA.

THREE AIRSHIPS REQUIRED LETTERED A, B AND C RESPECTIVELY.

| Day. | England. | | South Africa. | | |
|---|---|---|---|---|---|
| | Arrival. | Depart. | Arrival. | Depart. | |
| Monday ... ... | | A | C | C | 7 days' flying. |
| Tuesday ... ... | | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | |
| Saturday ... ... | | | | | |
| Sunday ... ... | | | | | |
| Monday ... ... | | B | A | A | 1 day's rest. |
| Tuesday ... ... | C | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | 7 days' flying. |
| Saturday ... ... | | | | | |
| Sunday ... ... | | | | | |
| Monday ... ... | | C | B | B | |
| Tuesday ... ... | A | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | 6 days' rest. |
| Saturday ... ... | | | | | |
| Sunday ... ... | | | | | |
| Monday ... ... | | A | C | C | |
| Tuesday ... ... | B | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | |
| Saturday ... ... | | | | | |
| Sunday ... ... | | | | | |

## TIME TABLE: ENGLAND—INDIA.

THREE AIRSHIPS REQUIRED LETTERED A, B AND C RESPECTIVELY.

| Day | England. | | South Africa. | | |
|---|---|---|---|---|---|
| | Arrival. | Depart. | Arrival. | Depart. | |
| Monday ... ... | | A | | C | 6 days' flying. |
| Tuesday ... ... | | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | |
| Saturday ... ... | | | | | |
| Sunday ... ... | C | | A | | 1 day's rest. |
| Monday ... ... | | B | | A | 6 days' flying. |
| Tuesday ... ... | | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | |
| Saturday ... ... | | | | | |
| Sunday ... ... | A | | B | | |
| Monday ... ... | | C | | B | 8 days' rest. |
| Tuesday ... ... | | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | |
| Saturday ... .. | | | | | |
| Sunday ... ... | B | | C | | |
| Monday ... ... | | A | | C | |
| Tuesday ... ... | | | | | |
| Wednesday ... | | | | | |
| Thursday ... | | | | | |
| Friday ... ... | | | | | |
| Saturday ... ... | | | | | |
| Sunday ... ... | C | | A | | |

Australia, taking practically the great circle course, advantage would be taken of the strong permanent westerly winds known as the "roaring forties." A complete new base with mooring mast would, of course, be required at Melbourne. For the return journey westward a course would be taken north of the outward journey, via Perth, where a mooring mast would be required, and advantage would be taken of the S.E. trade winds. The only small area of bad weather likely to be experienced would probably be between Madagascar and the African coast. It is considered advisable to place a mooring mast also in Ceylon, but were the return route made via Perth, Ceylon and Karachi you will see that it means crossing the monsoon area.

You have probably heard so much recently about the value of the mooring mast for ensuring regularity in airship traffic that I will not enlarge on the subject here, except to say that during the period of mooring mast experiments at Pulham, *i.e.*, from the 1st February to 30th June, daily flights were carried out, whereas at Howden without the mooring mast it was not possible to fly more than on thirty occasions, on account of not being able to get the ship out of the shed. This means 164 flights compared with 30.

There seems little doubt that following the steamship precedent, when airship traffic has become properly developed, the organisation will probably split itself into two companies—one to act as the air port or harbour company and the other to act as the operating company. I need not elaborate this point further; you will readily understand that the regulations which will have to be made regarding customs, fueling, etc., are bound to follow under these circumstances the lines of the conditions which exist in any maritime port.

### (*b*) Flying Organisation.

I have appended three time tables which demonstrate how five airships would be required on the Australian route, three on the Indian route, and three on the South African route, in order to maintain a weekly service both ways to each of these three colonies.

Taking first the Australian route, you will see that this would consist of seven days flying to Africa, a day's rest there, and three days further flying to Australia. The ship would then rest for minor overhaul three days before starting on its return journey. Having reached England it would rest ten days before setting out again. Taking next the Indian route, the ship would do six days flying out, one day's rest in India, six days flying back, and eight days' rest before setting out again. Finally, for the South African route, the airship would take seven days flying out, one day's rest, seven days flying back, and six days' rest before setting out again. These estimates are based on the assumption that a ship will carry out a complete journey from England to, say Australia, with the same load of passengers and goods without any transhipment en route, or without carrying out any inter-port traffic. To begin with, this would undoubtedly represent the state of affairs. Later on it might be necessary to consider running certain ships continuously, say between England and Cairo only, other ships carrying on from Cairo on the three routes. The reason for this is that the conditions of temperature and weather, etc., are so entirely different in the two cases; thus, for the first part of the journey, in order to cope with high winds, it might be necessary to instal sufficient engine power to allow high speeds to be attained. In the latter case, owing to the high temperature and hence low density of the air, it might be more advantageous to have a larger ship with not such high engine power in order to obtain the necessary lift. As far as possible it would be arranged to land in the early morning and leave in the evening, because the temperature is at its lowest then and hence the ship has its maximum lift, also weather conditions are as a rule most settled at these times. Sometimes very considerable temperature gradients exist in the tropics,

and for the ordinary type of gradient where the temperature falls with the increase in height, the height of the mooring mast (150ft.) may mean that the ship is able to leave for this cause one ton heavier than if it had started from the ground. It is, of course, the object of a ship's pilot to maintain his ship continually in static equilibrium as far as possible. A certain amount of error either way can be corrected by the use of the elevators, but this reduces speed. On long flights a certain amount of this correction is inevitable in order to economise the gas, and the pilot must be continually studying this point and working out problems of lift, in which temperature, barometer and weight of petrol consumed are the chief items, always with an eye to what is likely to happen twelve hours ahead. Naturally in the morning when the temperature is rising he must do nothing which would jeopardise the safe landing in the evening when the temperature is falling, and vice versa, in the hottest part of the day he will fly under clouds, where they exist, in order to avoid excessive heating.

As you probably know, it frequently occurs that the temperature of the gas in the airship is different from that of the surrounding atmosphere. This is known as superheating, and is a disadvantage to the pilot in giving a false idea of the lift of the ship. Experience on this point in the tropics is much needed. In most cases it is due to the direct heat of the sun and is therefore likely to be most serious near the Equator. The sun's intensity tends to increase with height whereas air temperature generally decreases, so that to reduce superheating it is advisable to fly low. It is also advisable to fly fast, in order to take full advantage of the cooling effect of the air flowing over the outer cover. Another condition which may be frequently encountered in the Tropics is an inversion temperature, *i.e.*, the condition in which the temperature near the ground is lower than the temperature at a height. Under these circumstances, of course, superheating would only be increased by flying low. The inversion temperature may cause trouble when leaving the ground if it is unexpected, because if a ship leaves the ground so that it is only just light it will be practically impossible to force it through the hot air above.

For those who are sufficiently interested to go further into this matter they cannot do better than study the admirable lecture which Major Scott gave to this Society in London on December 2nd, 1920 [AËRONAUTICAL JOURNAL, Vol. XXV., p. 47]. In that lecture you will find he has dealt very fully with all the problems of this kind with which a pilot is likely to be confronted on a long distance colonial route.

(*c*) **Meteorology.**

A most important and vital factor in the final success of the colonial airship service will be the state of our knowledge with regard to the meteorology of the upper air. It is now fairly common knowledge that the state of the weather on the surface of the globe does not give much true indication of what is happening at heights of, say 2,000 feet and more. At the present time there is practically no data regarding the variation of wind velocities and direction with height. The data which are available chiefly deal with anti-cyclonic conditions when the air is clear and a pilot balloon can be sent to a great height. It would, of course, be rare under these conditions to have to alter altitude to avoid bad winds. Major Scott gives it as his general experience that westerly winds increase with height, whereas easterly winds tend to decrease, both tending to turn anti-clockwise. The forecasting of weather from cloud formations becomes a fascinating and important study. The worker at sea level is obviously at a great disadvantage here, however; his view may be obstructed by low clouds of very little use to him, and he only gains occasional glimpses of the upper and really important air. In the trans-Atlantic flight of R.34 it was found that the weather over the Atlantic undisturbed by land behaved in a most orthodox manner and little trouble was experienced in forecasting. It was also found that in a good

many cases shallow depressions, in which an adverse wind of as much as 45 knots might be experienced, did not extend to heights of more than 5,000ft. Semi-permanent winds were discovered following more or less the junction line of warm currents and cold arctic streams. These winds occur at quite low altitudes and will probably be of sufficient utility to make it important that they should be carefully charted. Electric storms are perhaps one of the airship's worst enemies; the serious bumps and eddies which occur subject the ship to very considerable strains. There is some evidence, however, that they are generally confined to certain areas and to certain periods of the year, and also that they follow a very definite track. Here again the charting of these is of utmost importance. It appears from the communique which the Air Ministry issued to the Press on May 31st regarding the formation of a commercial airship company that the Government would be willing to assist such a company with all the resources at their disposal in the study of meteorology and in forecasting, etc. This offer would, of course, be of great value. Generally speaking, the information which would be of most use to the pilot would not be a series of forecasts transmitted to him by wireless telegraphy, but such a thorough study of the annual weather conditions as to enable him to make his own forecasts whilst flying.

### (*d*) Wireless Telegraphy.

Here again the Government have offered valuable assistance to a commercial airship undertaking. The study which requires most to be developed in wireless telegraphy in connection with airships is direction finding from the ship. The airship would require to carry a very high-powered installation for the direction finding to be done on land and the bearing transmitted to the ship. The scheme for an imperial wireless chain will ensure, it is hoped, a large number of high power stations being in operation in the not very distant future. If the airships are fitted with reliable direction finding apparatus they will be able to pick up these stations easily and obtain their own bearings.

## (7) Financial Organisation.

I should perhaps apologise to a scientific society like this for introducing the subject of finance at some length. I feel, however, that no paper on the organisation of a colonial airship service would be complete without some reference to the financial aspect, especially at the present time when a good deal of nonsense is being talked about the prohibitive cost of airships for transport. I will make no attempt to deal with the development period as there are so many different ways in which this development may proceed, but I will consider the state of affairs which may be expected when a service of one ship per week both ways to each of the colonies, India, South Africa and Australia, has been properly established.

### (*a*) Capital Costs.

The figures shown in Appendix I. are very similar to those given by the Imperial Air Communications Committee in their report, except that I have tried to present them in a more logical and intelligible form. With regard to the capital cost of twelve new airships, I am afraid I differ considerably from the estimate of the Committee. It is true that the rigid airships built by the British Government have cost on an average £350,000 each, but they have taken on an average one and a half years each to build and there has been no experience in building them on a production basis. The Germans reckon to take one year to produce a ship of an entirely new type, and after that two months for every ship of the same type on a production basis of say five ships. The Zeppelin Company built their ships during the war at a cost of about £150,000 and since the armistice have offered to sell the Americans a ship similar to those required for a

colonial service for £175,000. I therefore think that £200,000 is quite a fair estimate for ships built in England by a commercial concern on a production basis of twelve ships. My figures for the cost of a mooring mast station are slightly lower than those of the Committee, but they are nearly all taken from contractors' quotations, also I prefer to make an allowance for contingencies in a summary of costs at the end rather than to adopt the somewhat confusing practice of allowing for them several times over at various odd places.

The capital expenditure of new money required works out at about $4\frac{1}{4}$ million pounds (see Appendix I). A large sum, but not when the service to be rendered is considered. Not large in proportion when you consider the gigantic sums which have been sunk in harbours, docks, quays, lighthouses, etc., to aid steamship transport. No doubt a commercial concern would organise their bases, especially those abroad, so that the plant is fully utilised, possibly on engineering work of a local character in addition to its airship repairs, etc. Hydrogen plants might possibly be worked much more economically in conjunction with certain chemical manufactures. Pure hydrogen might be supplied for fat hardening or it might be produced electrolytically and the oxygen which is produced at the same time sold at a profit. One criticism which may be made of these estimates is that no allowance has been made for the purchase of land. You will readily understand that it is practically impossible to make even an approximate guess at this. Sites will necessarily have to be selected in the centre of low-lying ground, and if this is done a base will require about 500 acres and a mooring mast 200 acres.

(*b*) **Annual Expenditure.**

The question of annual expenditure is dealt with in Appendix II., under the headings of Maintenance Costs for Bases, Maintenance Costs for Mooring Masts, Annual Expenditure on Airships, Depreciation and Insurance. The maintenance costs which I have shown for Cardington are considerably lower than those given by the Imperial Air Communications Committee, but it should be borne in mind that the large part of the costs of labour at Cardington is included in the capital cost of building twelve new airships.

With regard to petrol, I have taken the figure of 2s. 6d. per gallon. The price has been reduced to this figure since the above Committee made their report, and there is little doubt that for a contract of 4,900,000 gallons per annum (which is the quantity that is estimated will be required), the price would be still further reduced.

Seven hundred million cubic feet of hydrogen will be required and I have put the price of this at 10s. per 1,000 cubic feet. I am fully aware that the Committee in their report have assumed the figure of £1 per 1,000 cubic feet, but this is the highest cost which has been experienced in the service for hydrogen production so far, and one of the largest manufacturers of hydrogen plants in this country has written to the Press saying that with modern developments and by the use of new plant, or with adaptations made to existing plants, the price need not exceed 6s. per 1,000 cubic feet. It therefore seems to me quite a fair compromise to take the figure of 10s. The figure of 7s. per day per person for passengers and crew has been included for food. As far as depreciation is concerned, the figure of $2\frac{1}{2}$ per cent. on buildings is a fair allowance for a factory plant and buildings, seeing that it covers all the items of capital expenditure and that liberal allowances have been made for maintenance. With regard to the airships, it is very difficult to form an exact estimate, as there are very few airships which have done sufficient continuous flying to show how long the structure will last, but granted that £10,000 per annum is being spent on each ship for material for maintenance, etc., the general opinion of the Germans and constructors in this country is that there is no reason why a ship should not last for five years. I have therefore taken the depreciation at 20 per cent.; 10s. per cent. has been

allowed as the usual figure for the insurance of the buildings and plant, but it is, of course, extremely difficult to say what is a fair rate for the insurance of the airships themselves. I have taken the figure of 5 per cent. It is possible that in the first place the company itself might be obliged to put aside a reserve fund for this purpose which might be considered as equivalent to insurance.

(*c*) **Revenue.**

The Imperial Air Communications Committee refrain with what is perhaps laudable temerity from attempting any estimates of the revenue to be derived from an airship service and draw attention to what they consider to be "the natural conservatism of the general public towards the adoption of new methods of transport." It would be rash indeed to attempt an exact forecast, but an examination of the existing volume of traffic together with the rates for freight and passengers reveal many interesting and helpful points. I have dealt with this subject in Appendix III.

Table A shows the present volume of traffic in first class passengers, parcels post, first class mail matter and certain items of special freight, some of which might possibly be carried by airship; unfortunately, I have not been able to obtain the tonnage figure for these items, but only the value. In Table B I have endeavoured to set out a possible estimate for traffic by airship. These figures are given with all reserve and are only intended to indicate some idea of the volume of traffic which would have to be carried to make the service a success, together with the revenue likely to be obtained under these conditions, with the rates shown.

As I have said already, a weekly service of one ship both ways to each of the colonies, Australia, India and South Africa, represents the minimum of what might be claimed as successfully improved rapid communication. I have also indicated that ultimately for a reliable service ships of four million cubic feet capacity will be required. The lift which such ships will have available for passengers and freight will be about 20 tons. Lest I should be accused of being unduly optimistic, I have based my estimates on the assumption that not more than two-thirds of their full capacity (*i.e.*, 14 tons) can be utilised. As far as passenger rates are concerned (in spite of the conservatism which may be experienced at first against this new form of transport), I feel that these will have to be kept as near as possible to existing steamship rates so as to attract as many people as possible at a low rate rather than a few at a high rate. It is only thus that the public will be educated to realise that the airship is not the precarious uncomfortable craft they imagine it to be at present. You will see that the passengers to be carried by airship according to Table B represent one quarter of the number of first class passengers which at present travel by other means. It does not seem to me at all unreasonable to suppose that this number could be attracted to travel by airship in the not very distant future, when one considers the benefits to be secured from the enormous saving in time. The great advantage of personal contact in business is only one factor which will cause many more to travel than before, and hence the volume of traffic will be automatically increased. The comfort of travel is another important factor. I will not hesitate to say that anyone who has taken a trip in an airship, such as R.36, will tell you that they cannot imagine a more easy and comfortable means of travelling.

To quote Sir Halford Mackinder, Chairman of the Imperial Shipping Board, "The airship offers the most satisfactory method of long distance travel yet invented." I would like to further quote so eminent an authority on another aspect of this question of passenger traffic by airship. How far will airship traffic react on existing means of long distance transport? What will be the effect on shipping companies and how will they regard it? Sir Halford Mackinder says:—

"Statesmen and merchants are in a hurry when they cross the world, but emigrants and cargo need cheap and therefore relatively slow carriage. Only in the case of the North Atlantic have you such great and wealthy populations on either side that you can retain a 25 knot service for passengers and leave cargo to be carried by tramps and the slower liners.

"In the Australian trade a compromise must be struck, for Australia and New Zealand have together only seven million people. While statesmen and merchants call for 20 knots an hour, and cargo can be most economically transported at 10 knots an hour, the statesmen and merchants are carried, grumbling, at 14 knots and the extra cost of pulling cargo along at such a pace is shared between them and the shippers, who, also grumbling, must pay higher freights than would otherwise be necessary.

"Steamships will in future be built of the most economical tonnage and speed, for they will no longer have to cater for passengers to whom time is more important than cost. Cargo and emigrants will, therefore, be carried at the lowest possible charges, a matter of vital significance, especially to Australia and New Zealand, both of them hungry for capital and for white population."

Similarly with regard to mails, half of which the table suggests should be carried by airship. At least half the first class mail must be business matter and I cannot imagine any business man objecting to paying 9d. and 6d. per oz. to Australia and India respectively when the saving in time will mean a definite increase to his business turnover. The interest to be saved on credit documents of all kinds by such rapid transport should surely prove a great attraction to him also. With adequate Government support, therefore, there appears to be no reason why the revenue to be derived from mails should not be of the order shown.

The question of how soon the specified amount of special freight traffic will be forthcoming turns very largely on how soon the insurance of such goods can be effected at a stable and reasonable rate. Let us hope that in the development period the airship will have so proved its capability for regular and safe transport as to enable this rate to be laid down with certainty. I have given some figures in Table A of some of the sources from which special airship freight might be drawn. The remarks I have just made with regard to the saving in interest on credit documents equally apply to bullion. Returns made in 1920 show that the bullion imported from South Africa was about £38,000,000 and that exported to India was £36,000,000. Assume that the time of transit in both cases is cut down from 21 to 7 days, then the saving on interest for 14 days at 5 per cent. on £74,000,000 works out at £154,000 approximately.

(*d*) **Cost Summary.**

Having dealt with the questions of capital costs, annual expenditure, and annual revenue, I will now summarise these figures, making certain additions for contingencies.

| | |
|---|---|
| Annual Expenditure (approx.) ... ... | £2,350,000 |
| Add for Contingencies ... ... ... | 250,000 |
| | 2,600,000 |
| Annual Revenue (approx.) ... ... | 3,150,000 |
| Annual Profit ... ... ... ... | 550,000 |
| Capital Expenditure (approx.) ... ... | 4,350,000 |
| Add for Contingencies ... ... ... | 500,000 |
| | £4,850,000 |

It will be seen that even with these liberal allowances for contingencies the annual profit represents 11 per cent. of the capital expenditure. Again let me emphasise the fact that the revenue figures are given with all reserve; the figures for capital and annual expenditure are, I think, fairly reliable. Once the service has worked up the traffic shown in Appendix III. there is no reason why it should not be quite a paying concern. This will take time, the development period will be a trying one during which any company will require large subsidies to enable it to raise the necessary capital to get going at all.

**(8) Future Technical Development in Commercial Airships.**

It was inevitable that the incentive of war produced very rapid developments in the construction of airships. Since the armistice the advances made have of necessity not been so great, nor yet so spectacular, but definite advances have been made, notably the development of the mooring mast. What is perhaps still more important is that a number of researches are just being brought to fruition, and these should have far-reaching effects. For this reason it is most unfortunate that the halt, not only in airship flying but also in research, should have been called at the present moment, leaving a number of valuable investigations so to speak in the air.

I will briefly outline some of these experiments and also some of the technical needs of the commercial airship of the future in the hope that they will stimulate the attention of engineers and men of science and that the new lines of thought will be productive of useful discussion.

(*a*) **The Airship Hull.**

You are all probably familiar with the general construction of the hull of a rigid airship. Although advance has been made in the various elements of the hull, there has been little or no tendency to depart from the general principle of the structure built up of transverse rings and longitudinal girders with the appropriate wiring. Alternatives have been suggested, such as a strong central beam with radiating spokes, and also a system in which the girders are arranged spirally round the hull from end to end. These ideas have not found favour with airship designers, either in this country or in Germany. Considerable success has been attained, however, with semi-rigid airships of fair size, and it is claimed for the Parseval semi-rigid P.L.26 that her performance was actually better than the Zeppelin rigid "Bodensee," which had about the same gross lifting power. Careful consideration should be given to the problem of determining up to what size, if at all, the semi-rigid possesses advantages over the rigid. Also it may be found that a type which is a compromise between the two might be successful up to still greater sizes.

Referring to the present scheme of hull construction, there is still room for considerable improvement. The original material used by the Zeppelin Company was aluminium. Their rivals, the Schutte-Lanz Company, who incidentally were responsible for a good many of the improvements contained in modern rigids, decided that wood was a superior material to aluminium. Later on the Zeppelin Company countered this by the use of duralumin, which is definitely superior to wood. This forced the Schutte-Lanz Co. to also consider duralumin construction, and they claim to have definitely made an advance on the methods of their rivals in using a tubular form of duralumin construction in their S.L.23. This ship was never completely assembled and most of the parts were destroyed or hidden before the Commission of Aeronautical Control arrived in Germany. As far as can be ascertained, however, plant had been put down for what had proved to be a perfectly satisfactory type of girder construction on tubular principles. The ship was to be one of about 2¼ million cubic feet capacity, which you will see is no larger than existing rigids and was definitely lighter for the same strength than

a ship built on the well-known Zeppelin principles. We have not been idle in this country on the same type of construction, but I am not at liberty to give you any further details at present. I think it fairly safe to predict, however, that the new ships of the immediate future will most probably be built on these lines. In changing over from airships designed for war purposes to those intended for commerce, it is probable that performance may have to be sacrificed for the sake of ruggedness of construction.

The question of the use of steel for the girder construction has been carefully considered. The Germans hold the opinion that this would not be satisfactory until capacities of over 8 million cubic feet are reached, and I think I am right in saying that airship constructors in this country would not care to use steel for a ship of less than 10 million cubic feet capacity. Research on an aluminium alloy to replace duralumin has attained very considerable success. This alloy should definitely prove superior from a mechanical point of view and is certainly much cheaper.

### (*b*) **Gasbags.**

The present system of constructing gasbags of light cotton fabric lined with goldbeater's skin is, as you are probably aware, a very tedious and costly one. The amount of labour involved is very considerable indeed, and it is safe to say were airships being used in comparatively large numbers, owing to their commercial development, the supply of goldbeater's skin in the world would not be sufficient to meet the demand. Work has been going on for a long time on a synthetic form of goldbeater's skin, which can now be made in long continuous rolls with an adhesive face and can be attached to the cotton by merely running the two materials through a callender. The Air Ministry were about to place a contract for two experimental bags made of this material when the order came to cease all further work.

### (*c*) **Hydrogen.**

The cost of hydrogen forms a very considerable item in the airship budget. The methods used for the production of hydrogen, both in this country and in Germany, had not been improved to any great extent by the end of the war. The method used is that known as the iron and steam contact process, in which iron is alternatively oxidised and reduced, the only difference being that in this country the multi-retort type of plant was used, whereas in Germany they developed the single reaction chamber type. The maximum thermal efficiency of either of these types is not much more than 15 per cent., and they were designed in pre-war days when coke was cheap. There is little doubt that great economies can be effected in this direction, and one of the big companies concerned in the manufacture of hydrogen plants are now giving the matter their careful attention, and consider that economies of 60 per cent. on the price of £1 per 1,000 cubic feet can be effected. The question of the production of hydrogen at stations abroad is a more difficult problem owing to the cost of fuel. In this connection some interesting experiments are in progress with the fermentation of vegetable matter. The results so far indicate that this is quite a hopeful field of research. The large quantity of matter available in Egypt, known as Nile sudd, is particularly interesting in this connection.

It is of the utmost importance to maintain a high purity in an airship itself because the loss entailed by the additional load of air carried is very considerable. As an example, in a 4 million cubic feet ship a drop of 1 per cent. in the purity produces an additional load of approximately one ton of air, which means, of course, an actual loss of one ton of cargo carrying capacity. It is a comparatively easy matter to get rid of the oxygen in the contaminated gas, but the nitrogen is a far more difficult problem.

You are all probably aware of the fact that, generally speaking, an airship has to valve a considerable amount of gas before landing, owing to the fact that she has become light during a journey by the weight of the fuel which she has burnt. One method of avoiding this waste would be to take some form of ballast on board whilst in flight were this possible. Experiments in condensing the water in the exhaust of the engines in order to gather ballast by this means have been commenced, but have not proceeded far enough to show whether they are likely to be ultimately successful or not. A better means of tackling the same problem would be to burn the hydrogen (which would otherwise be wasted) as engine fuel. It has not been found satisfactory to burn hydrogen alone in an aero engine, because it detonates very easily if more than about half full power is being developed. Researches which are being carried on at present, however, indicate that it is quite possible to use hydrogen in conjunction with petrol, and the saving which will be effected thereby is very considerable indeed. In fact, it may be said that it might possibly increase the radius of action of the airship by 50 per cent. If it were possible to use hydrogen in conjunction with crude oil the inflammability of the ship would be reduced enormously. This has yet to be investigated.

### (*d*) **Engines.**

There are reasons why a ship of a given size should have a number of engines of a certain horse-power rather than a fewer number of engines of a greater horse-power. Apart from the question of excessive concentration of load and thrust produced by engines of too great a horse-power, a large range of speeds will be obtained with greater economy by putting a certain power into a certain number of engines, rather than putting greater power into a fewer number of engines. It is considered that for airships up to 4 million cubic feet capacity engines of not more than 600 h.p. should be used. So far a satisfactory airship engine of this power has not been produced, and in the design of such an engine full account must be taken of the different conditions under which an airship engine has to run as compared with an aeroplane engine. The engine should be capable of running economically over a wide range of speeds without serious vibrational periods and also should be capable of running light without oiling up. The maximum efficiency of the engine should occur at that speed at which the engine may be run continuously for long periods. In this respect a good many aeroplane engines are unsatisfactory. It often occurs that an aeroplane engine when run at its maximum power on a test bench does give the maximum efficiency, but in flight for various reasons the maximum power is not obtained and then the engine performance falls considerably below that of maximum efficiency.

### (*e*) **General.**

For the purposes of economy of both time and expense it will be necessary to have the various parts of the commercial airship as easily replaceable as possible. It will have to be a simple and inexpensive matter to replace faulty or damaged girders, and as far as engines are concerned it will be necessary to have a unit which can be readily detached as a whole and which is interchangeable. The design of such a standard power car containing such accessories as a variable pitch propeller and exhaust heated steam boiler, etc., has been completed. The question of the heating, sanitation and lighting of the ship is one which needs a considerable amount of attention.

Somewhat erroneous ideas exist as to the dangers of fire in an airship. Fire may be due to two causes, the ignition of petrol or the ignition of the hydrogen

gas. If either of these has become sufficiently mixed with air the ignition may take the form of an explosion. Experience has shown that of the two causes the petrol vapour is by far the more serious. As I have already hinted, a solution to this is by the use of a heavy oil with a high flash point and research on this is going on. With regard to the hydrogen, generally speaking, in the ship the danger is not so serious as is commonly imagined, especially as the hydrogen cannot burn or explode until it has free access to the air. The use of helium to replace hydrogen, as I have already stated, has attracted a good deal of attention, especially in the United States, but the purification of the helium from the natural gas in which it occurs is a very costly business; also the known sources of supply are so very few that I have grave doubts as to whether the use of helium in commercial airships will ever become a practical proposition. It is quite probable, however, that sufficient helium could be stored to fill airships in wartime which had been normally flying filled with hydrogen. Research is more likely to take the lines of preventing all chances of a light getting to the gas, and in this respect it is not at all out of the question that on an airship of say 5 million cubic feet capacity an all-metal cover could be used. In the event of commercial airships being commandeered for naval or military purposes in wartime, the prevention of fire from incendiary bullets might also be effected in another way. It is possible that an envelope of nitrogen might be arranged to surround the gasbags in the space between them and the outer cover. Experiments have been conducted with a double balloon in which the outer space has been filled either with nitrogen or with the exhaust gases from an engine. In both cases incendiary bullets failed to ignite the hydrogen.

In the event of an airship finding itself over the sea with so little fuel as to very greatly limit her motive power, surface craft provided with mooring masts on them might be sent to its assistance. Experiments have already been made with the refuelling of an airship when attached to the mast of a surface craft which are very promising.

**(9) The Imperial Benefits of a Commercial Airship Service.**

The war gave this Empire a great lead in aircraft matters, and surely that lead should be jealously guarded now that peace has called on us to fly our aircraft to commercial uses. We have jealous rivals abroad, especially as far as airship matters are concerned. With airships as with aeroplanes, I cannot help sharing the opinion which has been so often expressed by many eminent authorities, that the country which would have the most powerful air arm for military necessity in future would be the one which has the most flourishing commercial air services from which it can draw aircraft in case of sudden necessity. Similarly with regard to bases and aerodromes. A well-established chain of commercial bases would be of immense value to military aircraft in time of necessity, but the cost of maintaining such bases in peace time for military preparations alone would be considerable and uneconomical. As a parallel case one may quote the fact that naval bases, landings, harbours, etc., are seldom, if ever, used by mercantile ships in peace time, whilst on the other hand, mercantile harbours are of very definite use to battleships in time of war. It is no secret that our naval authorities do still attach very considerable importance to the value of airships in assisting naval operations, and, in fact, I doubt if they would ever have consented to the complete abandonment of airships in this country had they not at the back of their mind some sort of assurance that a commercial undertaking would ultimately be formed to operate airships. On this they could draw in time of urgent necessity, very much in the same way as the navy itself originally grew out of our powerful mercantile marine. In this respect it will surely be conceded that the prestige which the British Empire would gain from a service of airships operating amongst its members would be enormous. It is

probably not fully realised that a modern airship could keep something like 100,000 square miles under observation in 24 hours, a task which would require at least six fast surface craft. Had we a proper system of airships guarding our trade routes during the recent war, I think that the career of the "Mowe" and the "Wolf" would have been a very short-lived affair.

His Majesty the King, in his reply to the loyal address of the Dominion Premiers, issued a call to the men of science to find some more rapid means for linking up the far-reaching boundaries of the Empire with the Motherland. I would humbly suggest that one of the many benefits which have been derived out of the terrible scourge of the war is that the men of science have already provided such an instrument in the airship, which I maintain is quite capable of fulfilling His Majesty's hopes and wishes in this respect.

**(10) Conclusion.**

I cannot close without some further slight reference to the tragic disaster of R.38. You will all have probably read by now the findings of the Service Court of Inquiry. A further very technical inquiry is being conducted which, I cannot help feeling (except for supplying further technical details), will only tend to confirm the general spirit of the findings of the Service Court. The lessons to be derived are quite clear and it is essential that the general public should fully understand these lessons, and not view the situation in any spirit of prejudice. The idea that the airship was lost for any mysterious cause should be completely dispelled. Such an idea naturally creates in the public mind the impression that there is something inherent in the nature of the airship which we do not know and which is, therefore, a continual and potential source of danger as we are unable to cope with it. The R.38 was an airship of a highly experimental character, calculated to give a performance for military purposes very considerably in advance of anything which had been built before. She was lost whilst carrying out trials of a highly strenuous nature, but not more strenuous than any commercial airship would be subjected to before it was allowed to carry passengers. I have little doubt that R.34 in crossing the Atlantic was subjected to far greater strains than was R.38 during her trials. As I have already indicated, the whole tendency in designing commercial airships would be to increase their ruggedness, even at the expense of making their performance less high than the performance called for in military ships during the war. With a ship cut down to such fine limits as was the R.38, every little portion of design requires most careful scrutiny. For this reason any lack of information on relevant aerodynamical data could be ill afforded. That some of these data were lacking there seems little doubt from the remarks of the Court of Inquiry. This surely points to the necessity for most careful and patient research on all scientific problems connected with the airship, including those on the aerodynamics of the subject.

At present in this country all airship research is at a standstill and, therefore, I cannot too highly commend the far-seeing and public-spirited attitude of this Society in endeavouring to raise a fund for airship research as a memorial to those who lost their lives in R.38. One thing more, it should be clearly realised that, although probably the majority of lives were lost through the fire and explosions which occurred, this fire only occurred as a result of the hull of the ship breaking into two portions. You will see, therefore, that it would be as unreasonable to say that railway travel was unsafe, owing to the dangers of fire, because in many cases of railway accidents trains have been badly burned, as it would be to say that airship travel can never be successful owing to the danger of fire which might occur, as in the case of R.38.

## APPENDIX I.

### CAPITAL COSTS (NEW EXPENDITURE).

| | | |
|---|---|---|
| **Ships.** | | |
| Twelve ships at £200,000 = ... ... ... ... ... ... | | £2,400,000 |
| **Mooring Masts.** | | |
| Re-erect Croydon mast at Cardington ... ... ... ... | | 4,000 |
| Cardington ... ... | | |
| Cairo ... ... ... | | |
| S. African route (2) ... | | |
| India ... ... ... | 8 at £47,600* = ... ... ... | 380,800 |
| Ceylon ... ... ... | | |
| Perth ... ... ... | | |
| Melbourne ... ... | | |
| **Bases** (Masts for these included in the above). | | |
| Melbourne (new) = ... ... ... ... ... ... ... | | 400,000 |
| S. Africa (new) = ... ... ... ... ... ... ... | | 400,000 |
| Cairo— | | |
| Transport and erect existing shed ... ... | £150,000 | |
| Hydrogen plant ... ... ... ... ... | 10,000 | |
| Gasometer ... ... ... ... ... ... | 20,000 | |
| Gas main ... ... ... ... ... ... | 4,000 | |
| Buildings ... ... ... ... ... ... | 10,000 | |
| Equipment ... ... ... ... ... ... | 4,000 | |
| Petrol storage ... ... ... ... ... | 4,000 | |
| Roads and siding ... ... ... ... ... | 20,000 | |
| Transport ... ... ... ... ... ... | 15,000 | |
| | ——— | 237,000 |
| Cardington— | | |
| Two new sheds ... ... ... ... ... | 500,000 | |
| Lengthen existing shed ... ... ... ... | 15,000 | |
| New gas main ... ... ... ... ... | 2,000 | |
| | ——— | 517,000 |
| | | £4,338,800 |

| | |
|---|---|
| ***Details of a mooring mast station.** | |
| Mast ... ... ... ... ... ... ... | £2,700 |
| Masthead ... ... ... ... ... ... | 500 |
| Three winches ... ... ... ... ... ... | 1,400 |
| Electric motors ... ... ... ... ... ... | 500 |
| Pumps ... ... ... ... ... ... ... | 200 |
| Lift ... ... ... ... ... ... ... | 900 |
| Mains ... ... ... ... ... ... ... | 2,000 |
| Cable ... ... ... ... ... ... ... | 2,000 |
| Foundations ... ... ... ... ... ... | 400 |
| Petrol storage ... ... ... ... ... ... | 2,000 |
| Gasometer ... ... ... ... .. ... | 20,000 |
| Gas main ... ... ... ... ... ... | 2,000 |
| Gas plant ... ... ... ... ... ... | 6,000 |
| Buildings ... ... ... ... ... ... | 1,000 |
| Equipment ... ... ... ... ... ... | 2,000 |
| Roads ... ... ... ... ... ... ... | 1,000 |
| Transport ... ... ... ... ... ... | 3,000 |
| | ——— £47,600 |

## APPENDIX II.

### ANNUAL EXPENDITURE.

| Bases. | Cardington. | Cairo. | S. Africa. | Melbourne. |
|---|---|---|---|---|
| Maintenance of base ... ... ... | £10,000 | £10,000 | £10,000 | £10,000 |
| Electric light and power ... ... | 5,000 | 5,000 | 5,000 | 5,000 |
| Advertising and office expenses ... | 10,000 | 6,000 | 6,000 | 6,000 |
| Personnel, wages and salaries ... | 55,000 | 40,000 | 40,000 | 40,000 |
| Transport ... ... ... ... | 1,500 | 1,500 | 1,500 | 1,500 |
| | £81,500 | £62,500 | £62,500 | £62,500 |

**Mooring masts (9)** ... ... ... ... ... ... ... Total £269,000

| | | |
|---|---|---|
| Maintenance ... ... ... ... ... | £1,000 | |
| Electric light and power ... ... ... ... | 1,500 | |
| Advertisement and office expenses ... ... | 1,000 | |
| Personnel, wages and salaries ... ... ... | 7,000 | |
| Transport ... ... ... ... ... ... | 1,000 | |
| | £11,500 | |
| Nine masts at £11,500 ... ... ... ... ... Total | | £103,500 |

**Ships (12).**

| | | |
|---|---|---|
| Crews (12) at £12,000 each = ... ... ... | £144,000 | |
| Petrol (4,900,000 galls. at 2s. 6d.) = ... ... | 612,500 | |
| Hydrogen (700 million cu. ft. at 10s. per 1,000) = ... ... ... ... ... | 350,000 | |
| Food for crews and passengers ... ... ... | 51,500 | |
| Material for maintenance (labour is allowed for in base personnel) ... ... ... ... | 120,000 | |
| Total | | £1,278,000 |
| London office expenses ... ... ... ... ... ... | | £30,000 |

**Depreciation.**

| | |
|---|---|
| Buildings and plant, 2½% on £2,200,000 ... ... ... | £55,000 |
| Airships, 20% on £2,400,000 ... ... ... ... ... | 480,000 |

**Insurance.**

| | |
|---|---|
| Buildings and plant, 10s. % on £2,200,000 ... ... ... | £11,000 |
| Airships, 5% on £2,400,000 ... ... ... ... ... | 120,000 |
| Grand total ... ... ... ... ... | £2,346,500 |

## APPENDIX III.

Table showing the yearly traffic of 1st class passengers, mails, parcels post, and certain items of special freight between Great Britain and Australia, South Africa and India.

TABLE A.

| Colony. | 1st Class Passengers. | | | | 1st Class Mail Matter. | | | | Parcels Post. | | | | | | Special Freight. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number. | | | Fare. | Tons. | | | Rate | Number. | | | Total tonnage (approx.) | Total value. | Rates. | Total value in and out. | | | | | |
| | Out. | In. | Total. | | Out. | In. approx. | Ttl. approx. | | Out. | In. | Total. | | | | Diamonds. | Fur. | Feathers. | Chemical Preparations. | Drugs. | Scientific apparatus (including films). |
| Australia, Tasmania, and New Zealand | 4,895 | 3,103 | 7,998 | £175 (Sydney). | 162 | 150 | 312 | 2d. for the first oz. 1½d. each additional oz. | 213,965 | 58,672 | 272,637 | 364 | £486,600 | 1/4 the first lb. 6d. each additional lb. | | £390,772 | | £531,331 | £431,501 | £261,830 |
| South Africa (including the Cape, Transvaal, Natal and Orange Free State). | 8,677 | 6,652 | 15,329 | £97 (Cape). | 185 | 170 | 355 | | 187,526 | 53,141 | 240,667 | 322 | £428,193 | 9d. per lb. | £5,470,899 | £337,806 | £1,232,161 | £671,750 | £192,886 | £75,102 |
| British India (including Bombay, Madras, Bengal and Burmah). | 14,637 | 11,586 | 26,223 | £90 (Bombay). | 255 | 230 | 485 | | 312,516 | 115,879 | 428,396 | 573 | £740,908 | Up to 3 lbs. 1/9. 7lbs. 3/6, 11 lbs. 4/9. | | £460,905 | | £446,047 | £521,131 | £158,528 |

The figures for special freight and parcels post are from Board of Trade Returns for 1914.
" " " passengers and mails are from official figures for 1920.

## APPENDIX III. (*continued*).

Table showing sketch estimates for the yearly traffic of passengers, mail and special freight with airships carrying out one trip per week both ways, utilising approximately two-thirds of their full capacity, *i.e.*, 14 tons (a 4,000,000 cub. ft. ship would have a capacity of 20 tons).

### TABLE (B).

| Colony. | There would be 104 trips per year. Assume that the *14 tons available on each trip is divided as shown. | Passengers. | | | | Mails. | | | Special Freight. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number. | Wt. Tons. | Fare. | Total Revenue. | Tons. | Rate. | Total Revenue. | Tons. | Rate. | Total Revenue. |
| Australia ... | 30 passengers and baggage = 5 tons ... Mail = 2 tons ... ... ... ... Special freight = 7 tons ... ... ... | 3,120 | 520 | £200 | £624,000 | 208 | 9d. per oz. | £279,552 | 728 | 6/- per lb. | £489,216 |
| S. Africa ... | 40 passengers and baggage = 6½ tons ... Mail = 2 tons ... ... ... ... Special freight = 5½ tons ... ... ... | 4,160 | 676 | £100 | £416,000 | 208 | 6d. per oz. | £186,368 | 572 | 4/- per lb. | £256,256 |
| India ... | 50 passengers and baggage = 8 tons ... Mail = 2 tons... ... ... ... Special freight = 4 tons ... ... ... | 5,100 | 832 | £100 | £520,000 | 208 | 6d. per oz. | £186,368 | 416 | 4/- per lb. | £186,368 |
| | | TOTAL REVENUE ... | | | £1,560,000 | | | £652,288 | | | £931,840 |
| | | | | | | | | | | GRAND TOTAL ... | £3,144,128 |

Comparing the above figures with those given in Table A, it will be seen that the total number of passengers proposed to be carried by airship represents 25% of those travelling at present by other means ; the amount of mail proposed to be carried by airship is 54% of the amount of mail carried at present by other means. It is difficult to find a basis of comparison for the special freight proposed to be carried—it represents, roughly, 1½ times the present weight of packages carried by parcels post.

* Representing two-thirds of full capacity.

# PUBLICATIONS.

The following papers, etc., are published by the Society in addition to the JOURNAL:—

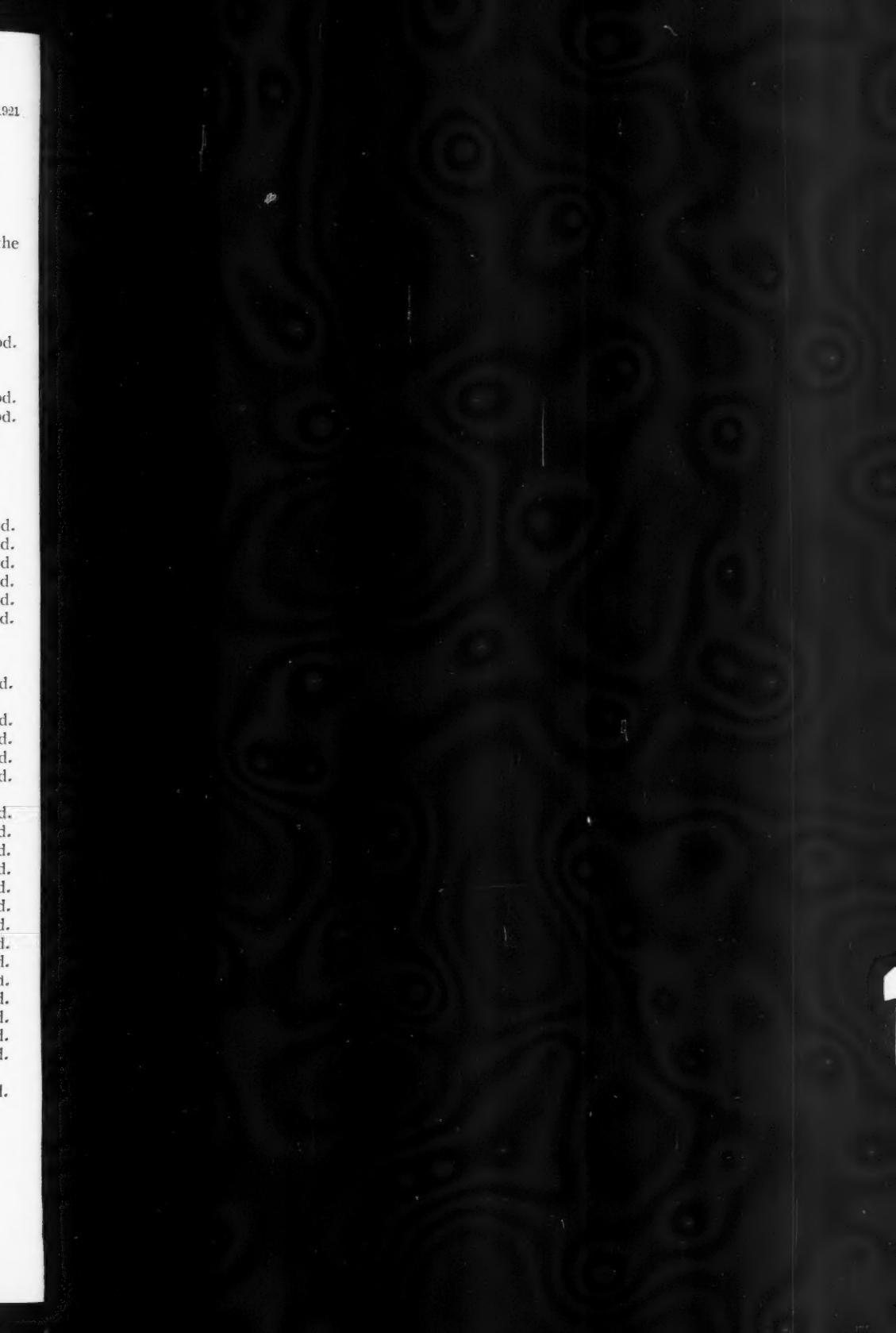
## Transactions.

1. "The Calculation of Stresses in Aeroplane Wing Spars," by Arthur Berry, M.A. ... ... ... ... ... ... 5s. od.
2. "Position Fixing in Aircraft during Long Distance Flights over the Sea," by Instructor-Commander T. Y. Baker, R.N., and Major L. N. G. Filon, D.Sc., F.R.S., late R.A.F. ... 5s. od.
3. "Aero Engine Efficiencies," by Dr. A. H. Gibson ... ... 5s. od.

## Aeronautical Classics.

*Reprints of the Work of Early Pioneers on whose theories modern flight is based.*

1. "Aerial Navigation," by Sir George Cayley (1809) ... ... 1s. od.
2. "Aerial Locomotion," by F. H. Wenham (1866) ... ... 1s. od.
3. "The Art of Flying," by Thomas Walker (1810) ... ... 1s. od.
4. "The Aerial Ship," by Francesco Lana (1670) ... ... ... 1s. od.
5. "Gliding," by Percy S. Pilcher (1897) ... ... ... ... 1s. od.
6. "The Flight of Birds," by G. A. Borelli (1680) ... ... 1s. od.

## Miscellaneous Publications.

"Steels Used in Aero Work," by Dr. W. H. Hatfield ... ... 5s. od.
"Methods of Measuring Aircraft Performances," by Captain H. T. Tizard ... ... ... ... ... ... ... ... 1s. 6d.
"The Screw Propeller in Air," by M. A. S. Riach ... ... 2s. 6d.
"The High Tension Magneto," by A. P. Young ... ... ... 5s. od.
"Commercial Aeronautics," by G. Holt Thomas ... ... ... 2s. 6d.
"The Training of Aeronautical Engineers," by R. M. Walmsley and C. E. Larard ... ... ... ... ... ... 2s. 6d.
"Steel Tubes for Aircraft," by W. W. and A. G. Hackett ... 2s. 6d.
"Timber," by W. H. Barling ... ... ... ... ... ... 5s. od.
"Design of Aeroplane Struts," by W. H. Barling and H. A. Webb 2s. 6d.
"Stress Optical Experiments," by Major A. R. Low ... ... 5s. od.
"Medical Aspects of Aviation," by Dr. L. E. Stamm ... ... 2s. 6d.
"Struts of Conical Taper," by H. A. Webb and Miss E. D. Lang 1s. 6d.
"Shop Practice in Respect to Aircraft Steel," by H. P. Philpot ... 5s. od.
"The Rigging of Aeroplanes," by R. J. Goodman Crouch ... 5s. od.
"Progress of Aviation during the War Period," by Dr. L. Bairstow 5s. od.
"Flight of Seagulls," by Dr. E. H. Hankin ... ... ... 1s. od.
"Chronology of Aviation," by H. Maxim and W. J. Hammer ... 1s. od.
"Report of the Bird Construction Committee" ... ... ... 10s. 6d.
"Glossary of Aeronautical Terms" ... ... ... ... ... 2s. 6d.
"London-Paris Service. Safety and Economy Committee's Report" ... ... ... ... ... ... ... 1s. 6d.